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AUTHORITY

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WADC TECHNICAL REPORT 56-585
Part II

EFFECTS OF TEMPERATURE-TIME-STRESS HISTORIES ON THE MECHANICAL PROPERTIES OF AIRCRAFT STRUCTURAL METALLIC MATERIALS

Part II. STRESSED EXPOSURE OF 7075-T6

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Materials Central
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Project No. 7360

WRIGHT AIR DEVELOPMENT DIVISION
AIR RESEARCH AND DEVELOPMENT COMMAND
UNITED STATES AIR FORCE
WRIGHT-PATTERSON AIR FORCE BASE, OHIO

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FOREWORD

This report was prepared by the Norair Division of Northrop Corporation under USAF Contract No. AF 33(616)-5769. This contract is a continuation of a previous contract, AF 33(616)-3028. This contract was initiated under Project No. 7360, "Materials Analysis and Evaluation Techniques", Task No. 73604, "Fatigue and Creep of Materials." The program was administered under the direction of the Materials Central, Directorate of Advanced Systems Technology, Wright Air Development Division, with Mr. R. F. Klinger acting as project engineer.

This report covers work conducted from May 1958 to September 1959.

Norair personnel responsible for this program included Messrs. D. M. Badger, C. D. Brownfield, and J. V. Griffin. The contributions of Metal Control Laboratories of Huntington Park, California, in their capacity as testing subcontractor are gratefully acknowledged. Primary technical personnel on this program at Metal Control Laboratories consisted of Messrs. R. E. Clark and J. N. Vinatieri.

Acknowledgement is also given to the authors of Part I for their constructive suggestions in this study.

This report is identified at Norair as NOR 60-16.

ABSTRACT

A study has been made on the problem of predicting strength of a hardened metal alloy after subjection to variable thermal and stress environments severe enough to cause permanent loss of properties. Methods have been developed for predicting tensile ultimate, tensile yield, and compressive yield strengths of 7075-T6 aluminum alloy after single or multiple exposures to various conditions of temperature and stress. An analytical expression suitable for automatic computing machine use has also been developed.

The results of tensile and compressive tests on alclad 7075-T6 aluminum alloy showed that stresses large enough to produce inelastic creep strain during thermal exposure cause reduction in residual strength after exposure. The test results have been used to establish the usefulness of the Larson-Miller exposure parameter for correlating residual strength after simple and complex, stressed and unstressed exposures.

PUBLICATION REVIEW

This report has been reviewed and is approved.

FOR THE COMMANDER:

W. J. Trapp

W. J. TRAPP
Chief, Strength and Dynamics Branch
Metals and Ceramics Laboratory
Materials Central

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NOMENCLATURE

Symbol	Definition	Units
D	$\left.\frac{F_{ef}-F_1}{F_f-F_1}\right\|_{T_f}$, strength deterioration factor describing F_{ef} in terms of its relationship to the strength interval between F_f and F_1 at any temperature T_f.	- -
F_f	Strength (F_{tu}, F_{ty}, or F_{cy}) at any temperature T_f with no previous exposure to temperature.	psi
F_{ef}	Strength (F_{tu}, F_{ty}, or F_{cy}) at any temperature T_f after exposure to T_e.	psi
F_1	Strength (F_{tu}, F_{ty}, or F_{cy}) at the given temperature after exposure to a reference exposure condition.	psi
F_{tu}	Tensile ultimate strength	psi
F_{ty}	Tensile yield strength	psi
F_{cy}	Compressive yield strength	psi
R_T	Strength reduction factor combining exposure temperature effects and test temperature effects. Ratio of strength-at-temperature-after-exposure to original-room-temperature-strength.	- -
R_ϵ	Strength reduction factor for effect of stress during exposure. Ratio of strength-after-stressed-exposure to strength-after-unstressed-exposure at the same value of Θ.	- -
R.T.	(Subscript) room temperature	- -
T_e	Temperature of exposure	$^\circ F$ or $^\circ R$
T_f	Temperature of strength test or of design condition after exposure.	$^\circ F$
t	Time	hours
Θ	Larson-Miller exposure parameter expressing equivalent combinations of exposure temperature and exposure time. $\Theta = T\,(C + \log_{10} t)$	(T in $^\circ R$)
Θ_{17}	$T(17 + \log_{10} t)$, the specific variation of Θ used in this report.	(T in $^\circ R$)
Θ'	$T(20 + 1.46 \log_{10} t)$, the variation used for 7075-T6 in Part I.	(T in $^\circ R$)
ϵ	Inelastic strain remaining after creep exposure.	%

INTRODUCTION

Modern flight vehicles are sometimes subjected to such severe thermal environments that the materials of which they are constructed suffer permanent loss in strength. Typically, these materials are hardened metal alloys which progressively lose strength during periods of exposure to temperatures at which the hardening mechanism is unstable. If stress is also present during the thermal exposure, as is often the case, this can have a further damaging effect on strength. Efficient design for such severe temperatures therefore requires a knowledge of how to predict the residual strength of structural materials after exposure to various histories of temperature and stress.

In the study reported here, empirical methods were established for predicting residual strength of aluminum alloy 7075-T6 in tension and in compression after such exposures. These methods are extensions of the approaches established by Fortney and Avery in Part I on aluminum alloys 7075-T6 and 2024-T3. The choice of 7075-T6 for the present study was made recognizing that this material is finding considerable use in moderate temperature applications and some use for limited times in higher temperature applications. Cost factors often make an aluminum alloy the best choice of materials for severe thermal and stress environments, providing accurate strength data are available. The methods of analysis developed in this study allow the use of the subject material to its practical limit in high temperature design.

In the most general form, these methods are based on curves which attempt to describe the characteristic deterioration or retrogression of strength with exposure, from fully hardened values toward annealed values. For unstressed exposures of 7075-T6 it was found that a single curve could be used to adequately describe characteristic deterioration of all strength properties considered (tensile yield and ultimate, and compressive yield) throughout most of the exposure range. For stressed exposures the same approach was used with modifications. Analytical methods for design use based on these curves are given in a special section presented early in this report.

For many other hardened materials it is considered likely that similar characteristic curves can be generated by applying the methods developed in this study. For materials which respond to thermal exposure in a more complex fashion than 7075-T6 or which have a markedly different response to stress during exposure, these methods would have to be modified, possibly toward a less general type of final curve.

The empirical approach used to define the characteristics of 7075-T6 in this study was as follows: .063 inch Alclad sheet coupons were subjected to a variety of exposure conditions and then tested at selected temperatures to determine residual short-time strength. Stressed exposures were studied by applying tensile stress during exposure with the amount of stress chosen to produce up to 1 percent inelastic strain -- about the practical limit for design based on short-time strength after exposure.

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The scope of the single exposure was:

Temp. range	250-600°F
Time range	1-100 hr
Stress range	0-50,000 psi (tension)*

The scope of multiple exposures was:

Temp. range	275-400°F
Time range	3.5-340 hr
Stress range	to 1 percent accumulated inelastic strain

The variety of multiple exposures included:

- 1-step, 2-step, 3-step, 4-step, and 10-step sequences
- Increasing temperature sequences
- Decreasing temperature sequences
- Mixed sequences
- Stressed sequences to various strain levels
- Stressed sequences with zero-stress soaking periods at start or end

The scope of final test conditions after exposure included:

Several mechanical properties:	F_{tu}, F_{ty}, F_{cy}, percent elongation, hardness
Several test temperatures:	R.T., 200, 300, 400°F
One strain rate:	.01 in./in./min. to yield
then:	.01-.05 in./in./min.

The presentation of information in this report is oriented from the standpoint of design use. Major results are presented first followed by substantiation and detailed descriptions. Illustrative material is grouped together at the end of the report for convenience in following references frequently repeated throughout the report. This places the graphs of final results (Figure 17 through 20) which are most useful for design applications just inside the back cover where they can be found quickly.

*Note: A spot-check of the effect of compressive exposure stress was also included.

BACKGROUND

Empirical methods for predicting residual strength of two aircraft structural materials after exposures to temperature alone, without stress have been developed in the first phase of this work, reported by Fortney and Avery in WADC Technical Report 56-585, Part I. The subject materials were 2024-T3 and alclad 7075-T6 aluminum alloys, and strengths in tension only were considered. The use of the Larson-Miller time-temperautre parameter for predicting the total effect of a sequence of differing unstressed exposures was successfully demonstrated in the aforementioned report. Extension of these methods to the case of stressed exposures and to design mechanical properties other than yield and ultimate strengths in tension was the purpose of the study reported here. Other studies, on alloys other than 7075-T6, have considered effects of prior creep on subsequent strength for creep strains ranging above about 0.5 percent (References 4, 5, and 6). None of these referenced studies were primarily concerned with development of methods for accounting for prior creep exposure effects in practical design cases.

CONCLUSIONS

A number of valuable conclusions can be drawn from the results obtained in the study. The limitations of these conclusions are cited in the text.

1. Stress applied during severe thermal exposure can significantly accelerate deterioration of strength in 7075-T6 (retrogression of strength level toward the level of the annealed state).

2. The degree of strength reduction due to exposure stress is associated with the amount of inelastic strain accumulated during exposure. It is dependent upon the total degree of thermal exposure but is affected only slightly by manner of exposure accumulation for the cases investigated.

3. The Larson-Miller exposure parameter can be used to define equivalent single exposures for determining residual tensile ultimate, tensile yield, and compressive yield strengths after single or multiple stressed or unstressed thermal exposures.

4. The general strength deterioration characteristics of 7075-T6 can be adequately represented on a single curve. Tensile ultimate, tensile yield, and compressive yield strengths and all final test temperatures are reflected in this curve. For stressed exposures, separate curves are required for different degrees of straining during exposure.

Based on these findings, analytical methods for determining allowable strengths in practical design situations have been developed. These are presented in the following section, together with limitations on their usage. Substantiation of both the conclusions and the methods can be found under experimental results.

In practical design situations it is sometimes necessary to predict allowable short-time strength after complex histories of temperatures severe enough to cause partial annealing and of stress severe enough to cause creep. "Short-time" or "static" failures as opposed to "creep" failures are a likelihood for environments in which there is considerable variation in the severity of stress-temperature cycles, and in which the severe stresses are of short duration. Such environments may or may not produce amounts of creep significant from the standpoint of design.

Analytical procedures for assessment of strength under such conditions are presented here. In the approach used, the failure is artifically separated from the spectrum, and thereby the effects of the prior history on the allowable strength remaining may be defined. The prior history is simplified by computing an equivalent exposure value for the temperature spectrum alone and by accounting for the effects of creep separately.

To find equivalent thermal exposures, the Larson-Miller exposure parameter, Θ, is used:

$$\Theta = T(C + \log t) \qquad (1)$$

where T is temperature in degrees Rankine, t is time in hours, and C is a constant. For the 7075-T6 data used in this report, the best value of C has been found to be 17, and the parameter becomes:

$$\Theta_{17} = T(17 + \log t) \qquad (2)$$

Given an actual spectrum of temperature exposures, the first step in computing the equivalent total exposure for 7075-T6 is to reduce each increment of exposure in the spectrum to a value of Θ_{17} using equation (2). Next, a single reference temperature, T_{ref} is chosen arbitrarily, preferably within the temperature range of the spectrum. The equivalent time at this temperature is computed using equation (2) for each of the previously determined values of Θ_{17}. Adding the results gives the total equivalent time at T_{ref} for the entire spectrum, as shown below:

Given Spectrum	Θ	Find Time at T_{ref}
T_1, t_1	$(\Theta_{17})_1$	Equiv t_1
T_2, t_2	$(\Theta_{17})_2$	Equiv t_2
T_3, t_3	$(\Theta_{17})_3$	Equiv t_3
.	.	.
.	.	.
.	.	.
		Total Equiv. Time

The equivalent total thermal exposure, Θ_{17} is now computed directly from equation (2) using the total equivalent time and the reference temperature.

The evaluation of a spectrum can be considerably simplified by using Figure 21. With this diagram the only calculation required for the above example is addition of the equivalent times at T_{ref}.

Once the equivalent total exposure is known, the assessment of its effect (if any) on strength can be made. It is useful to separately identify the major sources of strength reduction encountered. Strength is reduced as a result of: (1) duration of exposure to a sufficiently high temperature and (2) temperature at the time of failure. Combining these two effects, the residual strength after temperature exposure and at a given test temperature can be expressed as a function of original room temperature strength, as follows:

$$F_{ef} = R_T \, F_{R.T.} \tag{3}$$

where F_{ef} is residual strength (F_{tu}, F_{ty}, etc.), R_T is a strength reduction factor combining exposure temperature effects and test temperature effects and $F_{R.T.}$ is the original room temperature strength.

Stress during exposure, especially if high enough to cause inelastic strain, is another factor which may affect residual or final strength. It will be seen that stress did have a significant effect on the 7075-T6 material tested in this work. Including this factor, equation (3) above becomes,

$$F_{ef} = R_T \, R_\epsilon \, F_{R.T.} \tag{4}$$

where R_ϵ is a strength reduction factor for the effect of strain accumulated during stressed exposures.

Values of R_T, R_ϵ, and $R_T R_\epsilon$ obtained for 7075-T6 are shown in Figures 16 and 17 plotted against exposure value Θ_{17}. These were obtained from a program of single exposure tests and checked at key points by program of sequential exposure tests. F_{tu}, F_{ty} or F_{cy} values may be determined for a variety of exposure conditions and test temperatures using these data and equation (4). The $F_{R.T.}$ value used is the corresponding allowable room temperature F_{tu}, F_{ty} or F_{cy} (see Reference 7). Limitations on the use of these data are discussed at the end of this section.

It can be readily seen that the curves of Figure 17 are not sufficiently general in application to cover all test temperatures and exposure conditions which are practical for this material. A more general strength deterioration factor has been developed for 7075-T6 which relates all three types of strength F_{tu}, F_{ty}, and F_{cy} (and possibly others not tested) at all test temperatures. This factor is shown plotted in Figure 20(a) against exposure value Θ_{17}. In general terms, it represents a relative strength value where 1.0 is the fully hardened strength and zero is a reference (nearly annealed) strength. This strength deterioration factor, D, is:

$$D = \left. \frac{F_{ef}-F_1}{F_f-F_1} \right|_{T_f} \tag{5}$$

in which F_{ef} is the strength as tested after a given exposure, F_f is the original (fully hardened) strength, F_1 is the reference (nearly annealed) strength, and T_f is test temperature. For a given value of D, the F_{ef}, F_f and F_1 values must all be the same type of mechanical strength (F_{tu}, F_{ty}, or F_{cy}) and obtained at the same test temperature, T_f.

When Figure 20(a) is used as a design curve, F_{ef} is the unknown residual strength to be determined. Rearranging equation (5) for this purpose gives,

$$F_{ef} = D\,F_f + (1-D)\,F_1 \Big|_{T_f} \tag{6}$$

The appropriate value of D is obtained from Figure 20(a) for the particular total exposure value θ_{17} (obtained as before). Appropriate values of F_f and F_1 are chosen from Figure 19.

Notice that F_{ef} here is for the unstressed exposure case if D is taken from Figure 20(a). The same equation applies to stressed exposure cases if appropriate values of D are substituted. These are provided in Figure 20(b) for two stressed exposure cases involving, respectively, 0.2 percent and 1.0 percent inelastic strain accumulated during exposure. The proper value of D from Figure 20(b) is used in equation (6) above with appropriate values of F_f and F_1 from Figure 19 (as in the unstressed case) to find F_{ef} for a stressed exposure case.

No further explicit accounting for the effects of stress during exposure is necessary. For illustration, assume a design which meets the usual aircraft design criteria of 0.2 percent inelastic strain, as substantiated by methods not covered in this report. Then, any effects on residual strength of a spectrum of conditions within the design envelope are covered by use of the D value for 0.2 percent inelastic strain. Limitations are discussed at the end of this section.

For automatic computing purposes, an analytical expression is usually preferable to an empirical curve. Referring to Figure 20(a), an expression which fits the 7075-T6 data for unstressed exposure quite well throughout most of the exposure range and which relates D to θ_{17} is:

$$D = \frac{34{,}800}{(\theta_{17} - 12{,}920)^4 + 28{,}950} - 0.202 \tag{7}$$

$$(13{,}000 \leq \theta_{17} \leq 17{,}500$$

This value of D can be used in place of Figure 20(a) for unstressed exposures and F_{ef} can be found as before.

The added influence of stress during exposure can be taken into account by a simple correction which will suffice for many practical design situations. For example, assume that the design criteria restricts accumulated inelastic strain to 0.2 percent. From Figure 20(b) it can be estimated that for a considerable range of exposure values above $\theta_{17} = 14{,}500$, the effect of this

degree of inelastic strain is the same as adding a small increment of exposure value, approximately

$$\Delta\theta_{17} = 100$$

The new value of D can then be found using equation (7) above with the corrected value of θ_{17}, in this case $\theta_{17} + 100$, as

$$D = \frac{34,800}{(\theta_{17} - 12,820)^4 + 28,950} - 0.202 \qquad (8)$$

$$(14,500 \leq \theta_{17} \leq 17,500)$$

If accumulated inelastic strains significantly larger than 0.2 percent are permitted, a larger correction must be made. To correct for 1.0 percent strain, the appropriate increment of θ_{17} can be estimated from the curves of Figure 20(b) for each mechanical property. In many calculations, an average correction for the three properties will suffice and will simplify the calculations. In this case, for $\theta_{17} \geq 14,500$,

$$\Delta\theta_{17} = 250$$

may be used in equation (7) as in the previous case, and:

$$D = \frac{34,800}{(\theta_{17} - 12,670)^4 + 28,950} - 0.202 \qquad (9)$$

$$(14,500 \leq \theta_{17} \leq 17,500)$$

For θ_{17} values between 13000 and 14,500 the appropriate curve should be chosen from Figure 20(b) to suit the design conditions. For automatic computing purposes the chosen curve can be represented either analytically as was done above or as a set of coordinate values.

The effect of inelastic strain beyond 1 percent is not considered since prior creep strains of this magnitude are not likely to be permitted (except in very local areas) in cases where short-time strength is required after creep exposure.

It should be noted that the inelastic strain values of 0.2 percent and 1.0 percent used in this report are the strain accumulated during exposure only. The yield strength tests produce an additional inelastic strain of 0.2 percent. Thus, yield strength curves for 0.2 and 1.0 percent strain during exposure actually represent 0.4 and 1.2 percent total inelastic strain, respectively. The exposure stress was considered separately to provide a consistent treatment of yield and ultimate strength results. For a vehicle designed to criteria restricting inelastic strain to 0.2 percent total from any and all sources, the above methods would be conservative.

The above methods have some limitations and also possibilities of extension. These are outlined below.

Figure 20(b) shows that there is considerable difference between the stressed exposure curves for F_{ty}, F_{tu}, and F_{cy}, for exposures below $\theta_{17} = 14,000$. Here there is a very noticeable Bauschinger-type effect, which has a greater influence on strength than the factor of acceleration of the aging process through straining. In this region, only two exposure conditions were studied and the effect is only approximately defined. However, this effect is usually not taken into consideration in design except when yield strength is reduced (i.e.: when direction of testing is opposite to that of the original straining). The compressive yield curve for 1.0 percent strain can be considered an approximate minimum curve for cases of this type, providing stresses during exposure are no more severe (in causing strain) than used in the 300°F-1 hour condition tested.

Material variation must be considered in applying the results of this study. The curves of Figures 17 and 20 are representative only of the material tested in this investigation and should not therefore be used directly as minimum design curves. There is significant variation in the response of various lots of the subject alloy to exposure in addition to the normal variation in room temperature properties (see pg. 17). A suggested method of reducing strength values obtained from these curves to minimum allowable strengths is by reference to minimum design curves for 7075-T6 such as provided in Reference 7 (Mil Handbook-5). Comparison between equivalent data from this report and from the minimum design curves will indicate necessary adjustments in the curves of Figures 17 and 20. A better solution would be the development of true minimum curves of D versus θ. This could be done using the methods developed in this investigation, and, for the most part, existing data on 7075-T6.

It is felt that justification exists for cautious extension of most of the results to the case of compressive creep exposures. In the compressive creep exposure check test, 0.3 percent compressive creep strain had about the same effect on compressive yield strength as a like amount of tensile creep in the same intermediate exposure range (see Table VIII). It is not certain that like agreement would be obtained for larger amounts of strain. Also, it is probable but not certain that the Bauschinger-type effects noted for exposure values below $\theta_{17} = 14,000$ would be of the same magnitude for straining in compression as in tension. If Figure 20(b) is used to estimate the effect of compressive creep during exposure, the compressive yield curve should be used as the tensile yield curve, and vice-versa. This is to account for the reversal of Bauschinger-type effects.

Investigation of shear and bearing strengths was beyond the scope of this present work. However independent studies (not reported) using 7075-T6 shear and bearing data from Reference 8 have shown promise for application of Figure 20 to these failure modes. Until this is verified, shear and bearing strengths for unstressed exposures can be found from appropriate ratios to tensile values obtained for the given design conditions. It should be noted that these ratios are affected by test temperature and by approximate degree of exposure. Further studies of shear and bearing strengths after stressed and unstressed exposures are planned for further extension of this work.

Care should be exercised in applying the results of the study to conditions outside the scope of the test program. High rates of straining followed by testing in the direction opposite to that of the straining is one possible area for caution. Another such area is that of multiple tensile stressed exposures followed by testing in compression. In tests of this type, compressive yield strength was depressed slightly beyond expected values, most noticeably in the ten part sequence tests. It is not certain whether further strength loss might be caused by increasing numbers of cycles or even whether the effect is real. Care is therefore recommended in extending these results to much more complex sequences followed by compressive loading. For unstressed exposures, and for tensile properties following tensile stressed exposures the results indicate that extension to more complex sequences than those tested should be safe.

EXPERIMENTAL RESULTS

The foregoing conclusions and methods are based on the results of the test program outlined in Tables I and II. The purposes of the various tests are discussed below, then details of the program and the results obtained are presented and reviewed under the following sub-headings, in conjunction with the tables and graphs at the end of this report:

- Test Materials and Basic Properties
- Creep Characteristics of Material
- Tabulated Results
- Material Response to Thermal Expousre Without Stress
- Exposure Parameter Re-evaluation
- Effects of Stress During Single Exposures
- Effects of Stress During Multiple Exposures
- Variation of Stress Effects with Degree of Exposure
- Residual Strength After Single Exposures
- Accuracy of Prediction of Multiple Exposure Results
- Generalization of Results

Each test consisted of two principal parts for all exposure conditions, single or sequential:

> Exposure of Sepcimens -- Specimens were subjected to one of the selected temperature-time, or temperature-time-stress exposure conditions or schedules of conditions.
>
> Strength Testing After Exposure -- Standard short-time tensile and compressive tests were performed at room temperature or at one of the selected test temperatures.

The basic tests are the single exposure tests given in Table I. These tests provide data on stressed exposures, and they also form the foundation for examination of multiple exposures. The multiple exposure test program is presented in Table II.

Exposure temperatures, times, and stress levels shown in Table I were chosen to survey the effects of stressed exposure throughout the unstable range of the material from the T-6 condition to the nearly annealed condition. They were also chosen with the possibility in mind of using the Larson-Miller exposure parameter for stressed exposure cases as was done in Part I for unstressed exposure cases. In two cases, combinations of exposure time and temperature were approximately matched in total exposure value by two other combinations; this was done to check the assumed value of the constant C in the Larson-Miller exposure parameter. Values of this parameter using C = 17 (determination of which is discussed later) are presented for each exposure condition in the first column.

Exposure stress levels shown were established through creep tests and creep correlation methods. The target inelastic strain values were chosen to cover the range of anticipated practical use in design -- from a lower value

at half of the commonly used 0.2 percent to an upper value of 1.0 percent. Tensile exposure stress was used throughout to study stressed exposure relationships, and a spot-check case of compressive exposure stress was included.

The final test temperatures after exposure were selected to cover the temperature range of practical usage of the alloy with a minimum of tests as assisted by generalizing procedures.

Table II presents the multiple exposure tests. These tests provide data on a wide variety of sequential exposure conditions. The descriptions given in the table identify the main characteristics of the sequences chosen. Increasing and decreasing temperature trends at low, high, and zero stress levels at key values of total exposure are represented, as are some special cases with zero stress in the first or last step. Sequences range from two steps to ten steps.

Exposure temperatures and times were chosen to provide the desired total exposure and also to cause a significant change in properties in each step. The upper and lower limits of time used were 100 hrs. and 3.5 hrs., respectively, and temperatures ranged from 275°F to 400°F. Sequence total exposure values were chosen to approximately match the single exposure cases which had been checked by two different combinations of temperature and time.

Sequential exposure stress levels were established to give the indicated target strain values in the total sequence and also to produce significant strain in each of the stressed exposure steps.

Test temperatures after sequential exposures duplicated those of the single exposure program and were chosen with similar objectives. However, it was found that reductions in the number of final test temperatures could be effected without compromising objectives.

Test Material and Basic Properties

Test material for the entire program was 7075-T6 alclad aluminum alloy. Three .063 inches thick, 48 x 144 inch sheets of this material in the as-supplied T6 temper were used from Northrop Corporation production warehouse stock. All were from the same box of sheets from the material supplier.

The chemical analysis of each of the sheets, shown below, was well within the applicable specification (QQ-A-287) limits. Analyses were performed on a direct reading spectrograph.

PERCENT OF ALLOYING ELEMENTS

Element	QQ-A-287 Limits	Sheet A	Sheet B	Sheet C
Copper	1.2-2.0	1.70	1.60, 1.68	1.63
Magnesium	2.1-2.9	2.76	2.66, 2.58	2.70
Zinc	5.1-6.1	5.40	5.52, 5.48	5.50
Chromium	0.18-0.40	0.22	0.22, 0.21	0.22
Iron	0.70 max	0.10	0.18, 0.19	0.15
Silicon	0.50 max	0.06	0.05, 0.06	0.07
Manganese	0.30 max	0.10	0.09, 0.09	0.08
Titanium	0.20 max	0.02	0.02, 0.03	0.04
Aluminum	Balance	Balance	Balance	Balance

The microstructure of the test material was found to be typical of 7075 in the T-6 condition. Thickness of cladding was approximately 4 percent of the sheet thickness per side. A number of room temperature tensile tests were performed on as-received (unexposed) material from each sheet. All were well within the requirements of QQ-A-287.

Room and elevated temperature tensile and compressive properties of the test material before exposure are presented in Table III. The prefixes A, B, and C in the specimen nomenclature denote sheets A, B, and C which were utilized for the single exposure, tension; the multiple exposure, tension; and the compression program tests, respectively. The room temperature tensile tests performed on sheet A represent a survey of the sheet tensile properties. A total of 36 tensile tests were performed, to determine sheet variation and to provide tests to which nearby specimens exposed and tested could be compared. The latter improved accuracy in evaluating strength reduction factors in cases where strength values were near the original unexposed strength. The survey results are also shown in Figure 11, relating test values to location in the sheet. Variation in sheet A tensile properties was about average. The mean strength level was close to an universal mean for the same alloy and gage.

The aver[illegible] room temperature tensile properties of sheets B and C were approximately the same as sheet A. Room temperature compressive properties were determined only for sheet C. The average compressive yield of sheet C was 8.6 percent higher than its tensile yield, which is about normal.

Elevated temperature tensile and compressive tests in Table III are for unexposed specimens that have been heated to test temperature in a standard time of 12 minutes, from start of heating to start of loading. These data are shown plotted against temperature in Figure 19 (F_r curves).

Creep Characteristics of Material

Some knowledge of the creep characteristics of the material used in this study was needed to establish stress levels which would give the target values of strain during stressed exposure conditions. This need was filled by data from the literature and by check tests on each sheet of material.

Further refinements were required in methods for determining stress levels for succeeding steps in multiple exposure conditions. This was necessary because it was found that the creep strength of the material tended to decrease with progressive softening due to exposure. The strain values achieved during the various stressed single and multiple exposures are recorded in the tables of results. Analysis of creep characteristics is beyond the scope of this report.

Tabulated Results

The results of the experimental program are listed in Tables IV through XVI in the following order:

Table No.	Exposure Condition (Stressed & Unstressed)	Final Test	Nominal Test Temperature
IV	Single Exposure	Tension	R.T.
V	Single Exposure	Tension	200°F
VI	Single Exposure	Tension	300°F
VII	Single Exposure	Tension	400°F
VIII	Single Exposure	Compression	R.T.
IX	Single Exposure	Compression	200°F
X	Single Exposure	Compression	300°F
XI	Single Exposure	Compression	400°F
XII	Sequential Exposures	Tension	R.T.
XIII	Sequential Exposures	Tension	300°F
XIV	Sequential Exposures	Tension	400°F
XV	Sequential Exposures	Compression	R.T.
XVI	Sequential Exposures	Compression	300°F

The single exposure tables describe for each specimen the nominal and actual exposure conditions, the actual temperatures of testing after exposure, and the test results obtained. Actual exposure conditions consist of actual exposure temperature (the average temperature of the entire exposure) and the actual total inelastic strain obtained. The values of Larson-Miller exposure parameter θ_{17} are also shown.

Similarly, actual test temperatures are distinguished from nominal; it was found that at 400°F very small deviations in test temperature could be significant, also there were a few cases where "room temperature" was significantly above the 68°F to 75°F range.

In addition to the strength values actually obtained in tensile and compressive tests, values corrected to the nominal exposure and test temperatures are provided. This was done as a guide in evaluating the effect of temperature deviations and to give a better basis for comparing results. Correction consisted of adjusting test values by an increment of strength derived from final curves of the test results themselves and appropriate to the error in exposure value (θ_{17}) or test temperature. This is felt to provide a reasonably accurate correction because of the large amount of data available.

The strength results are also expressed in nondimensional form in the far right hand columns of these tables. The first of these, R_T is the ratio of the test value obtained to the material original unexposed room temperature strength. The second, R_ϵ , is the ratio of stressed exposure test results to the parallel unstressed exposure results, or a reduction factor for the effect of stress alone in the exposure environment.

The sequential exposure tables follow the same general pattern as the single exposure tables, but modifications are made to accommodate the multiple exposure steps. Nominal exposure conditions are shown; actual exposure temperatures are omitted but were used to compute the total exposure value θ_{17} listed for each specimen. Actual strains accumulated during each exposure step are shown below the nominal conditions. Actual strains accumulated during the entire sequences are also presented. The properties after exposures and strength ratios are treated in the same manner as in the single exposure tables.

Material Response to Thermal Exposure Without Stress

The results of the single exposure tension tests are plotted in Figure 12 together with similar results from Part I to compare the response of the two lots of material to thermal exposure. The form of the Larson-Miller parameter, θ', established for 7075-T6 in Part I is used as the abscissa. Values of this form of the parameter are not shown in the tables because another form of the parameter is used for the balance of this report. However, values of θ' can be readily computed from the equation given in Figure 12. The ordinate is nondimensional strength as established in Part I.

The test data plotted are from Sheet A of the present study and represent the averages of all identical tests. These data are connected with solid line curves, and the data from Part I are shown by dotted line curves.

Comparing the results from the two lots of material, it can be seen that the material from Part I responded to exposure significantly earlier in time (or in θ') than did the material in Sheet A. Similar disagreement in proportional effect of exposure has been found in comparison of results from comparable exposure and test conditions from various sources (i.e.: Reference 8). This is a factor of material variability that must be considered in applying results of a study of this type of practical situations. Methods of approximately accounting for this variability are discussed under Analytical Methods for Design.

Another difference in results from the two studies is also illustrated in Figure 12. It was originally assumed that the θ' form of the Larson-Miller parameter used in Part I would also apply to the material used in the present program. This assumption was checked by the tests in which different combinations of exposure time and temperature gave the same value of θ'. Test data plotted in Figure 12 at these values of θ' (θ' = 17,400 and 18,500) show that imperfect agreement was obtained with the θ' form of the parameter. Considerably better agreement was obtained when the parameter was modified. This is discussed in the following sub-section.

Exposure Parameter Reevaluation

Reexamination of the Larson-Miller exposure parameter showed that

$$\theta_{17} = T(17 + \log t)$$

provided the best fit for the data from the material in the present study (the change to a single constant is discussed below). The results using the new constant in the parameter are shown in Figure 13. The better agreement for the ultimate strength of Sheet A is immediately apparent (the 376°F-3 hr. data point should be ignored for the moment, since it is from Sheet C and was not shown in the preceeding figure). The yield strength curves show similar good agreement for both Sheet A (tension yield points) and Sheet C (compression yield points).

There is thus the indication that the best constant for use in the parameter may change with different lots of material. The degree of change in this case can best be seen by converting the earlier θ' into the single-constant form by dividing by 1.46:

$$\frac{\theta'}{1.46} = T(13.7 + \log t)$$

Thus, the change in constant is effectively from 13.7 to 17. The change to the single constant form of the Larson-Miller parameter in this report is made because this has become the more widely used form.

Effects of Stress During Single Exposures

The effects of stress applied during exposure can be most simply discerned by comparing results for stressed and unstressed exposures having otherwise identical conditions. This may be expressed in ratio form as:

$$R_{\epsilon} = \frac{F_{\text{stressed exposure}}}{F_{\text{unstressed exposure}}}$$

R_{ϵ} is thus a strength reduction factor for the effects of stressed exposure, and the strain subscript ϵ is used because the value of this factor appears to be primarily dependent upon the amount of inelastic strain accumulated during exposure. R_{ϵ} is easily found from the test data because unstressed exposure control specimens were included with each group of three specimens subjected to stressed exposures. The control specimen test results are given in Tables IV through XI just above the associated stressed exposure results. R_{ϵ} is shown in the tables and is obtained by dividing the individual stressed exposure final strength values by the average of the control specimen final strength values.

Study of the ratios in the tables shows that exposure stress (or strain) in general does have an effect on remaining strength of 7075-T6, but this effect is not large. R_{ϵ} ranges from about .85 to 1.05 depending on degree of thermal exposure and degree of strain produced during exposure.

Figure 14 shows the R_ϵ values from the single exposure conditions plotted against inelastic strain. Each individual test result is plotted. Separate plots are made for each strength property measured and for each degree of exposure utilized. Results for all final test temperatures are plotted together. An interesting and useful observation can be made: Final test temperature after exposure has no significant effect on the reduction factor due to stress applied during exposure. This can be confirmed by careful examination of all cases plotted in Figure 14.

In Figure 14, rough scatter bands are indicated by shading to show the basic trends of the results. These scatter bands are drawn arbitrarily in view of the small net effect that precision of establishing these bands has on the final resulting strength. The shading of the bands is stopped just above 1 percent strain because that is the upper limit of the range of interest in this study. However, points with larger strain were considered in drawing the bands.

Included in these bands are key markings (small, black "x" marks) at 0.2 percent strain and at 1.0 percent strain for use in later analysis. These marks are plotted at the approximate mean value of the test data, to the nearest 0.01 value of R_ϵ. A small degree of smoothing of the location of these marks across neighboring exposuring conditions was done (up to 0.01 R_ϵ). The scatter of individual test points about the key points is within 3-1/2 percent for most cases.

At the lowest value of exposure, Figure 14(a), no scatter band is established because only large-strain tests were run. Comparing the key points shows that stress during exposure had no appreciable effect on the tensile ultimate strength but it raised the tensile yield strength and depressed the compressive yield strength. This is similar to the Bauschinger effect observed in specimens which have been prestrained in tension (at room temperature) and then tested either in tension or compression (Reference 10). The comparison seems logical since the exposure stress in the 300°F-1 hour case was quite high, and a relatively large part of the resulting strain was probably plastic strain on loading.

At moderate exposure values, Figures 14(c) through 14(g), this pronounced effect has disappeared and the scatter bands for all three properties are depressed, with compressive yield reduced slightly more than the tensile properties. In this area, the predominant effect of strain during exposure seems to be an acceleration of the process of everaging or annealing. However, a small degree of Bauschinger-type effect appears to persist to fairly high exposure values.

At extreme exposure values, Figure 14(h) and 14(i), the effect of stress during exposure on remaining strength is diminished and the R_ϵ values again approach 1.0. In this exposure range, there may be a tendency for ultimate strength to be least affected and compressive yield the most affected.

Effects of Stress During Multiple Exposures

The effect of creep stress during the sequential exposures is presented in Figure 15. The manner of presentation is similar to that of the single exposure results discussed in the previous section, so that visual comparisons may be made at nearly equivalent exposure values (θ_{17} values). Direct comparisons of single and multiple exposure results are presented later in the report. In comparing the single and multiple exposure curves it is valuable to note that the vertical scale of these plots is a rather expanded one, so that any real differences should be easily detected.

Examination of the curves in Figure 15 shows that of the sequence variables considered. There is little evidence of greater strength reductions than found in comparable single exposure tests. The one sequence in which a noticably different result was obtained is the D sequence shown in Figure 15(e). In the D exposure sequence, specimens were unstressed until the last fraction of exposure period, at which time an exposure stress which gave a relatively high rate of straining was applied. Reductions in final strength caused by exposure strain in D sequence tests were not as great as in tests at similar values of strain and exposure value θ_{17}, in which the strain was more uniformly accumulated. The results from these tests indicate that the stressed exposure strength reductions can be affected to some degree by extreme non-uniformity in strain accumulation.

Slightly greater strength reduction than expected was obtained in compression tests after the stressed E sequence (10 Part) exposusre, shown in Figure 15(f). It is not certain whether this effect is real since it is small in magnitude especially considering the number of test results defining it and their scatter. The results obtained raise questions as to the effect of further increases in number of steps in sequences. Additional tests would be required to definitely establish the nature of this effect.

The various types of sequential exposures serve to demonstrate that, except for unusual exposure conditions such as the D sequence, (and possibly the case of compression after very complex stressed exposures, as noted above) the results are independent of the type of sequence used. Thus, it may be assumed for a large number of practical problems that if the sequence is sufficiently well mixed to avoid radical situations, consistent results can be expected from all sequences in the range covered by this study.

Variation of Stress With Degree of Exposure

As noted above, the effect of stress during exposure on the subsequent residual strength varies with degree of exposure. Figure 16 shows this variation; the key points for 0.2 percent and 1.0 percent inelastic tensile strain from Figures 14 and 15 are replotted as a function of θ_{17} to show the trends of the mean values of the scatter bands with exposure.

The curves were drawn through the single exposure key points only (x symbol) for several reasons: (1) to establish a set of single exposure R_{ϵ} values to be used in later analysis, (2) to provide a basis to which stress

effects in multiple exposure tests could be compared, and (3) to provide a basis for some smoothing of single exposure key values across adjacent exposure conditions. Key points are omitted and dashed lines are used where R_ϵ curves had to be interplated or extrapolated to obtain values at either 0.2 percent or 1.0 percent strain. Multiple exposure key points (+ symbol) are plotted for comparison with single exposure results.

The maximum effect of exposure stress and the trend of this effect with single exposures are easily discerned from this figure, since the effects of scatter are minimized. It can be seen that for 1 percent accumulated tensile strain during exposure the maximum effect on residual strength is about 8 percent for tensile ultimate, 10 percent for tensile yield and 11 percent for compressive yield. At very early exposures, greater differences between the effects in the three cases are noted, as discussed earlier. For 0.2 percent inelastic strain, the maximum effects are about 3 percent of tensile ultimate, 4 percent of tensile yield, and 2 percent of compressive yield. The differences at 0.2 percent strain are considered smaller than the accuracy of definition of the trends.

It is of interest to note the shapes of the yield curves for 1 percent strain during exposure as compared to that of the ultimate tensile curve. The compressive yield minimum is both lower than that of the tensile yield and occurs earlier. While the tensile yield minimum even occurs later than that of the tensile ultimate. Apparently a small degree of Bauschinger-type effect persists to relatively high exposure values. Possibly, much shorter exposure periods than those investigated, with rapid accumulation of strain during exposure would emphasize this effect. However, it is significant that there was no apparent difference in this effect between 10 hour and 100 hour tests at approximately the same exposure value.

In Figure 16, the multiple exposure results follow much the same pattern as the single exposure results for tensile ultimate and yield strengths. Compressive yield, on the other hand shows a possible tendency toward more strength loss in multiple exposures than in single exposures, most noticeable in the 10 step sequence, as noted in the previous discussion. Comparison of single and multiple scatter bands at equivalent exposures for the compressive yield cases indicates that the difference is slight for the variety of cases covered. The cause of this difference, if a real effect, is not identifiable from these tests. Additional studies are desirable to check the existence of this effect.

The small net error introduced in predicting multiple exposure results for sequences within the scope of this investigation is treated in later discussions of the accuracy of prediction. The D sequence is the one case in which marked difference was obtained. In Figure 16, the D sequence points for tension ultimate and tension yield after 1 percent strain fall quite high, near the 0.2 percent strain curve, at $\theta_{17} = 15{,}300$.

Residual Strength After Single Exposures

In the foregoing discussion, the strength reduction factor for stressed exposure has been based on the strength after unstressed exposures. Strength after unstressed exposure is reduced as a result of: (1) duration of exposure to a sufficiently high temperature and (2) temperature at the time of failure. These effects can be combined and the total strength reduction for unstressed exposure expressed as the ratio:

$$R_T = \frac{\text{Strength at Temperature After Unstressed Exposure}}{\text{R.T. Strength Before Exposure}}$$

For stressed exposure the reduction factor for the effect of stress, R_ϵ is included in the expression for total strength reduction, as:

$$R_T R_\epsilon = \frac{\text{Strength at Temperature After Stressed Exposure}}{\text{R.T. Strength Before Exposure}}$$

Expressed in these terms, stressed and unstressed exposure results can be plotted on the same coordinates, providing curves that are more general than obtained by plotting actual strengths.

Figure 17 shows the F_{tu}, F_{ty} and F_{cy} strength reduction factors R_T and $R_T R_\epsilon$ plotted as a function of exposure value θ_{17}. Trends of R_T values are indicated by the solid curves. $R_T R_\epsilon$ values for 1.0 percent strain during exposure are shown connected by dashed curves. Each R_T data point represents an individual unstressed exposure test result. These values are also listed in Tables IV through XI. Values of $R_T R_\epsilon$ were obtained by applying R_ϵ values for 1.0 percent strain from Figure 16 to the R_T curves.

Correlation of unstressed exposure results with the Larson-Miller parameter as modified for this study appears good, as was noted previously in discussion of Figure 13. The stressed exposure results indicate that although inelastic strain during exposure does affect strength, it does not impair this correlation. This can be seen by reference to Figures 14 and 16. As noted in previous discussion of these figures, in cases where different combinations of time and temperature gave approximately the same exposure value θ_{17}, the effect of inelastic strain on final strength was nearly the same.

The general effects of inelastic strain during exposure can be seen by examination of the curves of Figure 17 for all strength properties and final test temperatures. First, it is observed that the effect of up to 1.0 percent inelastic strain on the residual strength of 7075-T6 is not large but is significant. Second, the effect is nearly the same in all cases at a given exposure value except in the lower exposure values. A third observation is that for a large part of the exposure range the stressed exposure results are offset from the unstressed exposure results by approximately a constant increment of exposure. These observations make possible a much simplified, general approach for predicting the effect of stressed exposures presented in this report.

Accuracy of Prediction of Multiple Exposure Results

Use of the single exposure results to predict multiple exposure values for the same total exposure has already been suggested for unstressed exposures in Part I and for stressed exposures in foregoing discussions. Comparison of the accuracy of such predictions is given in Figure 18 for the three strength properties investigated and for unstressed and stressed exposures. The actual results achieved in test after multiple exposures are plotted against values predicted from the single exposure curves for the same calculated total Θ_{17} exposure. The solid line at 45 degrees in each chart represents perfect agreement.

Unstressed exposure correlations are shown in Figure 18(a). Individual points reflect averages of all results for each sequence. Coding is provided to identify the different sequences investigated. Agreement between predicted and actual results is in general quite good. One difference can be detected between results from certain exposure sequences. Considering sequences identical except for the temperature direction of the exposure steps, decreasing temperature steps resulted in slightly higher strengths than increasing temperature steps. This can be seen by comparing the open and closed symbols having the same shape. Even with this difference, the agreement between predicted and actual results is good.

The stressed exposure correlations are shown in Figures 18(b) and 18(c) for 0.2 percent and 1.0 percent inelastic strain. In this case the test values for comparison with predicted values were derived by using the key values of R_ϵ (for 0.2 and 1.0 percent strain) for the stressed multiple exposure cases from Figure 15. Each key R_ϵ value was multiplied by the R_T value for the sequence it represented. This removed the scatter of individual test results as was done for Figure 18(a). Also, the R_T values for sequences identical excepting for direction of temperature steps were averaged, removing the difference noted previously for different temperature directions of unstressed exposure sequences. (No distinction in stress effects was noted for this case, see Figures 15(a) and (c)). Since accuracy of the R_T value prediction in Figure 18(a) was good (especially with temperature direction effect averaged), Figures 18(b) and 18(c) clearly indicate any additional inaccuracy due to the effect of stress (or strain) during the various sequences.

The results for the stressed exposures are similar to those found for the unstressed exposures. The correlation between predicted and actual test results is generally very good. The maximum difference is noticed in the case of the D sequence. Another smaller difference can be detected. This is for compressive yield strength after the ten-part E sequence. Both of these results were discussed under "Effects of Stress During Multiple Exposures."

Generalization of Results

It is valuable to generalize the foregoing results in order to simplify and extend application to practical problems. This can be accomplished by finding ways to relate as many variables as possible to each other on a common basis. This has already been partly accomplished by the general correlation of all test results with the form of the Larson-Miller parameter used.

Closer examination of the various curves in Figure 17 shows that all material strengths do not deteriorate to the same degree with prolonged exposure. Room temperature tensile ultimate strength declines to 50 percent of its original strength while room temperature tensile yield and compressive yield strengths decline to about 20 percent. This means that any relationship which exists between the magnitudes of these various strengths must be non-linear and is not entirely obvious from the empirical data. However, these curves have some similarities. It can be seen that in all cases deterioration of properties begins to occur at a common degree of exposure and becomes essentially complete at another common degree of exposure. Similarity can also be seen in the general shapes of the curves. This leads to the supposition that a single general shape of decay curve might be followed by all strength properties in traversing the interval between full-hard strength and full-soft strength.

Attempts were therefore made to plot all properties tested in terms of relative strength between full-hard and full-soft strength, against the exposure parameter θ_{17}. This was not too successful, due to a rather large degree of scatter which occurred in tests at extreme exposures (see plotted data for 600°F-8 hours in Figure 17(c)). Attempts to approximate the same results by using a more restricted interval have been met with success. The interval between the original strength and the strength remaining after an exposure of $\theta_{17} = 16{,}380$ (450°F-10 hr.) was chosen as the reference interval. The strength values for the extremes of this interval (for the three sheets of material used in this study) are shown in Figure 19 as a function of temperature. All other strength values are related to their position in this interval by the expression:

$$D = \left. \frac{F_{ef} - F_1}{F_f - f_1} \right|_{T_f}$$

in which D is called the strength deterioration factor, F_{ef} is the strength as tested after a given exposure, F_f is the original (full hardened) strength, F_1 is the strength after the reference exposure (450°F-10 hr.) and T_f is test temperature. For a given value of D, the F_{ef}, F_f, and F_1 values are all the same type of mechanical strength (F_{tu}, F_{ty}, or F_{cy}) and obtained at the same test temperature, T_f.

Values of D for unstressed exposures are computed in Table XIX using data from Tables IV through XVI for F_{ef} values, and Figure 19 for values of F_1 and F_f. F_{ef} values used are average values from each group of specimens tested under identical conditions. The results are plotted in Figure 20(a), where all of the unstressed exposure data from the program are shown together on one curve; all three types of mechanical properties at all final test temperatures after single and multiple exposures are represented. It can be seen that the correlation throughout most of the exposure range is good while that at extreme exposure (nearly fully annealed) is poor. Fortunately, the useful portion of the curve is the region of good correlation.

The same procedure is applied to the stressed exposure cases by relating them to the unstressed exposure results. The F_r and F_1 values are unstressed exposure values, while the F_{ef} values are for stressed exposures. Calculations for D are given in Table XIX for 0.2 percent accumulated inelastic strain and for 1.0 percent accumulated inelastic strain during exposure. In these cases, F_{ef} is found by applying the strength reduction factors, R_ϵ from Figure 16 to the same unstressed exposure average values of F_{ef} used for the basic D curve.

The results for the stressed exposure cases are shown in Figure 20(b). Here, the data points are omitted for clarity of presentation. The curves for the different properties are practically the same for most of the unstable (steeply sloping) region of the curve and are shown as a single curve for 0.2 percent and another for 1.0 percent. At the low exposure values, the stressed exposure curves for the three properties separate, particularly the 1 percent strain curves. The magnitude of the effect is considerable below $\theta_{17} = 13,500$. In this region the curves are primarily based on only one exposure condition (300°F-1 hr.) and it is not certain that the same curves would hold for all exposures.

All of the test data developed in this investigation have been successfully normalized by means of the procedures which have been discussed. This raises the question of extension to mechanical properties other than those tested. It should be recognized that the normalizing procedures used in this report are basically empirical, and therefore, the resulting strength deterioration curves apply specifically to those mechanical properties for which data were obtained. However, an analysis of data from reference 8 (the results of which are not shown here) has indicated that the shear and bearing properties of 7075-T6 after various exposure conditions can very likely also be normalized by the same procedures. For unstressed exposures, shear and bearing properties may even follow the same strength deterioration curve (Figure 20(a)). The hardness data obtained in this investigation on the other hand, does not plot directly on the same curve, probably due at least in part to characteristics of hardness magnitude scales.

It is believed that the basic approach used in this work on 7075-T6 can also be used in investigating many other hardening materials which deteriorate in strength during exposure to practical thermal and stress environments. Modifications to the approach will no doubt be required, especially for materials having more complex aging or annealing characteristics than 7075-T6.

TEST PROCEDURES

The procedures used in this program were established and checked prior to use in an attempt to attain the accuracy desired in each part of the exposure and of subsequent tests. The consistency of the results achieved tends to verify the adequacy of the procedures. The important features of these procedures are discussed under the following subheadings:

- Specimen Identification and Preparation
- Specimen Exposure Assemblies
- Specimen Exposures
- Measurement of Creep Strain
- Specimen Processing Between Exposure and Strength Testing
- Hardness Testing
- Strength Testing

Specimen Identification and Preparation

Three 0.063 gage Alclad 7075-T6 aluminum alloy sheets were used during this investigation. Specimen blanks were marked out on heavy adhesive-backed paper covering the sheet, with the axis of all test specimens transverse to the original rolling direction. These were identified by metal stamping according to the identification system shown in Figure 1. The sheet was sheared into specimen blanks and machined to the dimensions shown in Figure 2. Careful machining practices were used, and microhardness tests on machined surfaces showed that machining caused no overheating of the material.

Specimen details are shown in Figure 2. The tension specimen incorporates pin-joint type loading ends, 0.505 inch reduced test section and 2.0 inch gage length. This same specimen was used for both creep-exposure and tensile testing after exposure. Tensile creep-exposure specimens for the compression test program were essentially extra long tensile specimens with a slight machining allowance on the width so that all edges of the compression specimens could be machined to the required tolerances. The compression test specimen was 0.5 in. wide by 2.75 in. long. Three of these specimens were machined from the reduced section of each creep-exposure specimen.

Specimen Exposure Assemblies

Stressed exposure of tension specimens was accomplished for the most part with three specimens linked in series as shown in Figure 3. Unstressed control specimens were exposed along with the stressed specimens, mounted (by one end only) adjacent to the center stressed specimen. Small aluminum blocks were loosely assembled to cover the reduced section of the upper and lower stressed specimens. The use of these blocks improved temperature stability with no detrimental effects other than a slightly slower heat-up rate. Thermocouples were placed at each end of the reduced section of each specimen until enough temperature data were accumulated to allow reduction of the number of thermocouples to that shown in Figure 3.

Some of the one hour and ten hour stressed exposures of tensile specimens were effected in shorter length creep furnaces one specimen at a time. Thermocouples were located at each end of the reduced section of all such specimens. No temperature stabilization blocks were required.

All thermocouples were attached so as to contact the edge of specimens. This location was checked against thermocouples located in drilled holes in a dummy specimen and found to be an accurate procedure. (Temperature deviation between edge location and hole location was found to be less than 1°F as long as reasonably uniform furnace temperatures existed. For rapid heat-up conditions, the edge thermocouples responded more rapidly to increase in furnace air temperatures than did the thermocouples in holes.)

Stressed exposure of material for compression specimens was accomplished with the creep exposure specimen shown in Figure 2. Unstressed exposure specimens consisted in most cases of 0.625 in. by 3 in. blanks. These were mounted in the center of a second creep exposure specimen which acted as a carrier only. The carrier specimen was mounted (by one end) parallel to the stressed exposure specimen separated by about 0.25 in. In a few cases a long creep-exposure specimen was utilized for unstressed exposure compression specimens, mounted the same as the "carrier" specimen described below.

A total of four thermocouples were used to instrument the ten-inch long reduced section of the stressed exposure specimen. A single thermocouple sufficed for the zero stressed specimens, all of which were in mutual contact.

Specimen Exposures

Most specimen exposures were performed in the type of creep machines shown in Figure 4. Exceptions were some short duration unstressed exposures and the compression creep exposure check test which were exposed in the circulating-air oven.

Creep Furnace Exposures:

Specimen assemblies were installed in the furnace and heated to the desired temperature as rapidly as possible, using caution to avoid temperature overshooting of any of the specimens. Specimens were then loaded by gently adding weights to the weight pan. The time for heat-up, from start of heating to start of loading averaged one-half hour (the creep furnaces were limited in rate at which specimens could be heated with accuracy, especially when utilizing a large proportion of the furnace length).

Thermocouple temperatures were recorded continuously throughout all exposures on multi-channel recorders and checked periodically with a precision potentiometer (the latter readings also recorded). Variation in temperature of a given point throughout the exposure period was within $\pm$ 5°F from the average temperature, after the first hour of exposure. Usually, for the first hour temperature was less stable, within about $\pm$ 7.5°F (excepting the 300°F-1 hr exposures, discussed further below). Temperature variation during exposure over specimen 2 inch gage lengths was within 3.5°F. The temperature records obtained

were used to determine specimen average temperatures for the entire exposure period. These are the actual exposure temperatures recorded in Tables of Results along with nominal exposure temperatures. Actual temperatures were up to $\pm$ 4°F from the nominal exposure temperatures.

At the conclusion of the exposure period specimens were unloaded, removed from the furnace, disassembled from all linkage, and allowed to cool on a wood surface.

Procedures for each of the exposures in sequential exposure tests were the same as above except that specimens were usually transferred to a different creep furnace for each part of the sequence. This was done because it was found that rapid heat-up could be obtained more accurately by starting with a cool furnace.

An analysis was made of effect of heat-up time for the various exposure conditions. The conclusion was that the only exposure condition in which this became important was the 300°F-1 hr condition. The check test on the effect of compressive creep exposure (375°F-3 hr) was also short enough to have been in this category, but these exposures were performed in a circulating air oven which provided more rapid heat-up. For the short exposures in the sequential exposure program heat-up times were incorporated approximately into the calculation of total exposure for the sequence (Θ value) and so were negligible in the effect on the net accuracy of the sequence.

The 300°F-1 hr exposures were given special attention and, for the tests that were reported, heat-up times were held to 15 minutes, with good temperature stability achieved throughout the exposure period. This heat-up time amounts to a possible error in exposure value of plus 50 units of Θ_{17}. The appearance of the strength reduction curves (Figure 17) at this exposure indicates that this error is negligible as to effect on strength level. Similarly, this error has a negligible effect on the determination of the effects of stress during exposure. This can best be seen in Figure 16.

Circulating-Air Oven Exposures:

A few unstressed exposures were performed in the circulating air oven used for elevated temperature strength tests, shown in Figure 6. These were relatively short exposures, from 3 to 10 hours in duration. The specimens for each exposure were bound together and a thermocouple was attached to each end of the group. The heat-up time was 15 minutes or less except for the 600°F-8 hr exposure; one half hr was required for 600°F stabilization. Thermocouple temperatures were determined periodically with a precision potentiometer and recorded by hand.

Compressive Creep Exposure:

The compressive creep exposure check test followed procedures identical with the elevated temperature compression tests. The same specimen was used, supported in the compression test fixture while subjected to a predetermined compressive stress. With each of these were exposed one unstressed compression and one unstressed tension specimen as controls. Compressive creep exposure specimens were undistorted after stressed exposure and no machining was required between exposure and compression test.

Measurement of Creep Strain

Creep strain was measured by using two sets of gage points of the type shown in Figure 5. One had about 2" separation and the other slightly less. The larger set was impressed in the reduced section of the specimens before exposure and the smaller set was impressed within the first set after exposure. The separation between the resulting points at each end of the gage length was measured under a microscope with a Filor eyepiece, at a magnification of 100 power. The sum of the two measurements was equal to the total inelastic strain in the 2 inch gage length plus the original difference in lengths of the two sets of points.

To calibrate this system, it was necessary to know precisely the differences in lengths of the two sets of gage points. To accomplish this, each time a group of specimens for exposure was marked, trial impressions were made on a dummy strip. The differences between sets of points on the test strip was measured precisely under a microscope as before. Variation in creep strain measurement was checked and found to be within approximately $\pm$ 0.02% strain for the single exposure measurements.

For the long creep exposure specimens, the same procedure was followed in each of the three locations from which a compression specimen was to be machined.

For specimens subjected to multiple exposures, total creep strain accumulated was determined after each exposure step. This was done with succeeding sets of gage marks laterally displaced (up to 0.035 in.) from the original set. It was found that accuracy of creep strain measurement was reduced by the lateral displacement of gage marks. Performance checks indicated that maximum variation of measured sequential exposure strain from the actual was about 0.06%.

Specimen Processing Between Exposure and Strength Testing

Tensile Specimens:

For tensile specimens, steps between exposure and tensile testing consisted of: creep strain measurement, hardness testing (if applicable, see below), and holding at room temperature for a standard delay time. The first two items are discussed elsewhere under test procedures. The standard delay time is explained as follows: Up to 1 1/2 hours were required to complete tensile tests of some groups of specimens exposed together. To minimize differences between specimens as to holding time at room temperature before testing, it was decided to delay start of testing for a standard time of one hour after the end of the exposure period. This step was taken against the possibility of minor changes in strength due to secondary ageing reactions at room temperature after exposure to temperature.

Compression Specimens:

Steps between exposure and compression testing consisted of:

Creep strain measurement
Cutting compression test blanks from reduced section of creep exposure specimens
Hardness testing (if applicable)
Refrigeration storage of compression test blanks
Machining of compression specimens from blanks

All of the above steps are explained elsewhere or are self explanatory except the fourth. Refrigeration of compression test blanks was used to avoid long and variable soaking times at room temperature caused by the intermediate machining step. Blanks were refrigerated to below 5°F within an hour after the end of exposure and held from a minimum of 12 hours to a maximum of four weeks before bringing back to room temperature for machining and compression testing. Time at room temperature for machining and compression testing varied from 3 to 8 hours. Total time at room temperature between exposure and compression testing was therefore from 4 to 9 hours for all specimens.

The effect of refrigeration was checked on unexposed control specimens for room temperature test. Two such specimens were refrigerated for about 16 hours while several specimens located near these in the sheet were not. All were compression tested at room temperature. No effect of refrigeration could be discerned in the results (Table 3).

Hardness Testing

All specimens for room temperature strength tests were hardness tested after exposure and before strength testing. Two Rockwell hardness scales were used because of the wide range of hardness of specimens after exposure, the B scale and the H scale. Most specimens were tested on both. Location of hardness tests on tensile specimens was at each end of the reduced section. Compression test blanks were hardness-tested at each end on material subsequently removed in machining of compression specimens.

A number of hardness test results on creep-exposed tensile specimens have been omitted from the results reported. These tests were performed just outside the specimen reduced section, through error, on material which had been subjected to a lower exposure stress than that in the reduced section. These values would not have been completely representative of the material which was subsequently strength tested and so were deleted.

Strength Testing

Tensile Tests:

After exposure, tensile specimens were tested at one of four test temperatures, room temperature, 200°F, 300°F or 400°F, using the equipment shown in Figure 6 for the elevated temperature tensile tests and most of those at room temperature. Properties determined were ultimate tensile strength, 0.2% offset yield strength, and percent elongation. Yield strength values were obtained from autographic stress-strain curves using extensometers over a two inch gage length. Percent elongation was measured over a two inch gage length with dividers.

Specimen temperatures were measured by a thermocouple contacting the specimen edge at the midpoint between ends of the reduced section. In tests to verify this procedure, there was no difference between readings of thermocouples located in holes drilled in the specimen and those at the edge location, nor was there any significant temperature difference from top to bottom of the reduced section. Temperature was read from a precision potentiometer. Readings were recorded at the start of loading and at maximum load. The actual test temperatures given in the tables of results are the averages of these two values, which were never more than 3°F apart.

The maximum time for heating specimens to test temperature was 12 minutes and this was for the 400°F test temperature. Less heat-up time was required for the 200°F and 300°F test temperatures, but a standard heating time of 12 minutes before loading was also used for these. Times from start of loading to the 0.2% offset yield load and to maximum load were obtained on elevated temperature tests, using a stopwatch. Time to yield varied between 20 seconds and one minute. Time from start of loading to ultimate load varied between 45 seconds and 3 1/2 minutes. (At 300°F and 400°F test temperatures maximum time was 2 1/2 minutes.) An exception to this were tests on the nearly annealed material (600°F-8 hr exposures). Some of these required 5 minutes to reach maximum load.

All tension tests were performed with a constant rate of crosshead travel from start of loading to fracture. A few of the first room temperature tensile tests were performed on a Baldwin SR-4 test machine at a strain rate of 0.005 in/in/min up to yield, with the aid of strain pacing. Shortly thereafter the Instron Machine, with a circulating air furnace (Figure 6) became available, and strength testing was changed over to this machine. The strain rate up to yield for tests conducted on the Instron Machine averaged 0.01 in/in/min. Data provided in Reference 11 indicate that a change in strain rate of this magnitude should not significantly affect the results of tensile tests on 7075-T6 at room temperature.

Strain rates up to yield were calculated from readings of time to reach the 0.2% offset yield load. These values varied from the average value quoted above, depending on the strength level of the material and the test temperature. All strain rates fell within 0.008 and 0.012 in/in/min. This degree of variation would be undesirable for tests at 400°F on this alloy; however, nearly all of the 400°F tests fell within 0.008 and 0.01 in/in/min. The few that did not were tests of material in the nearly annealed condition. Actual strain rates up to yield for tests at 400°F are given in the tables of results (see Tables III and XVII).

Strain rate in the specimen reduced section tended to increase after yielding, the usual case when crosshead travel rate is held constant throughout tensile tests. (With specimen yielding the change in stress rate causes a change in distribution of strain between the specimen reduced section and other parts of the linkage between the test machine crossheads.) Actual strain rates from yield to ultimate were not obtained, however all fell between approximately 0.01 in/in/min and 0.05 in/in/min. The latter is the maximum possible rate with the 0.1 in/min crosshead separation rate used. Also, specimens of approximately equal strengths tested at the same test temperature would have had comparable strain rates from yield to ultimate.

Compression Tests:

After single exposures compression specimens were tested at one of four test temperatures, room temperature, 200°F, 300°F or 400°F; and after multiple exposures at room temperature or 300°F. 0.2% offset compressive yield values were obtained from autographic stress-strain curves. Test facilities were the same as for tension tests.

The fixture for supporting compression specimens during tests is shown in detail in Figure 9 and in place in the test machine in Figure 10. Specimens were supported by guide plates having offset vertical grooves. Specimen alignment in the fixture and tightening of guides were by "feel". Strain was measured by a two inch averaging extensometer, using extension arms for elevated temperature tests. Accuracy of compression test procedures was checked by inspection of modulus of elasticity values from a number of compressive and tensile stress-strain curves obtained at room temperature and 300°F.

Specimen temperatures were measured by a thermocouple attached to the edge of one of the specimen guides, at the midpoint between specimen ends, about 0.125 in. from the specimen surface. The test furnace and fixtures were stabilized at the test temperature before installing compression test specimens.

Maximum time for specimens to reach any of the test temperatures was slightly under 12 minutes, so heating time was standardized at 12 minutes for all elevated temperature compression tests. This agreed with the heating time for elevated temperature tension tests. Maximum time from start of loading to the 0.2% offset compressive yield load was 1.2 minutes.

The accuracy of compression specimen heating was checked with a dummy specimen which had thermocouples located in grooves at the top, middle and bottom in addition to the thermocouple on the specimen guide. No significant temperature disagreement occurred between any of the thermocouples when procedures which simulated compression tests were followed.

Compression tests were performed with a constant rate of crosshead travel. Strain rates as determined by stopwatch readings averaged 0.009 in/in/min for all tests. Individual values obtained varied between 0.007 and 0.001 in/in/min with a few exceptions. Part of this variation is probably due to the method of measuring strain rate. All tests at 400°F fell between 0.0075 and 0.0095 in/in/min. Strain rates for 400°F tests and for the exceptions noted above are recorded with the test results (Tables III, XI and XVI).

TEST EQUIPMENT

Equipment used in the experimental portion of this investigation can be conveniently divided into two categories.

Exposure Equipment: Equipment used to provide the desired exposure conditions for specimens prior to testing consisted of:

- Creep-rupture machines
- Temperature recording equipment
- Creep strain measurement equipment

Test Equipment: Equipment used for tensile, compressive and hardness testing of specimens after exposure consisted of:

- Tension and compression test equipment
- Compression test fixture
- Load-strain recording equipment
- Hardness tester

Creep-Rupture Machines

Stressed and unstressed exposure of specimens was carried out on several creep rupture machines. Six of these on which most of the exposures were performed were of the type shown in Figure 4. These are Arcweld M-3 creep frames with cylindrical wire-wound resistance furnaces, 32 inches long by 2.5 inches inside diameter. Specimen loading is by weights acting on a lever. Furnaces are controlled by Wheelco 407 current proportioning, indicating controller in conjunction with a chromel-alumel thermocouple mounted on a specimen in the center of the furnace.

Three Arcweld XJ creep frames were also used. These had 22 inch long by 4.5 inch inside diameter wire-wound resistance furnaces. Function of the XJ units is similar to the M-3 units previously discussed. Furnace control is by Brown Electronik electropulse proportioning recording controller.

Temperature Recording Equipment

Specimen exposure temperatures were continuously recorded on one of two Brown Electronik 12-channel recorders. These recorders have a rated accuracy of 0.25 percent of full scale temperature range. The scale used was zero to 1200°F. Specimen temperatures were periodically checked with a Leeds and Northrup model 8662 precision potentiometer. Thermocouples used throughout all tests were made of special close tolerance 24 gage chromel and alumel wires joined by flash welding. Thermocouples were within ± 1°F accuracy in the temperature range of usage.

Creep Strain Measurement Equipment

Apparatus for measurement of creep strain consisted of two sets of gage points, one of approximately 2 inch separation, the other slightly less than

2 inches. One of these is shown in Figure 5. The points used in these gage marking devices are Rockwell Diamond Point Indenters. Actual measurement of the separation of the two sets of points at each end of the 2 inch gage length was accomplished with a Bausch & Lomb bench microscope with Filor eyepiece at a magnification of 100 or 125 power.

Tension and Compression Test Equipment

Two test machines were utilized for tension tests. A few of the first room temperature tensile tests were performed on a Baldwin SR-4 hydraulic universal testing machine, with a 50,000 pound maximum capacity. This machine is equipped with a Baldwin strain pacer operated from the extensometer differential transformer. The remainder of the tension tests and all compression tests were performed on an Instron TTC-M1 test machine, shown in Figure 6. Tests on the Instron machine were run at a constant rate of crosshead travel. A stopwatch was used to measure time from start of loading to the .2 percent offset yield load and maximum load. For elevated temperature tests, a circulating air electric-resistance oven manufactured by Missimers Inc. was employed (shown in Figures 6 and 7). This oven has a working chamber 15 inches wide by 12 inches high and 22 inches deep.

Furnace temperature was controlled by a Brown Electronik electropulse proportioning recording controller, in conjunction with a chromel-alumel thermocouple located in the furnace working zone.

Compression Test Fixture

The compression test fixture consisted of a pair of adjustable specimen guides, a loading system and a base for the specimen. Details of the fixture are shown in Figure 9. The compression test assembly is shown in Figure 10.

In this fixture, specimen guides have vertical grooves offset from each other. This has been indicated as a generally acceptable specimen supporting arrangement in Reference 9. The specimen is loaded at the top by an unattached blade which is supported by the guides and protrudes slightly at the top of the guides, where it contacts a loading ram. The blade thickness is a slight undersize of the specimen to avoid binding in the guides. Load is transmitted through a 5/8 inch diameter ball in the ram assembly to assist in alignment of loading.

Material used in the frame, guides and loading ram is A-286 alloy, with Stellite No. 1 hard facing in highly loaded areas. The loading blade is hardened tool steel. The ball is a standard ball bearing which is replaced upon any sign of plastic deformation.

Load-Strain Recording Equipment

A Baldwin PS-5M microformer extensometer was used to measure strain in all tensile tests. This extensometer is an averaging, separable type. For tests at room temperature, 200°F and 300°F, it was attached directly to the specimen with opposing conical points, over a 2 inch gage length. For tension tests at 400°F extension arms from a different extensometer were used with the PS-5M. These were also attached to the specimen with opposing conical points

over a 2 inch gage length, with the arms extending outside the furnace. The installation for tests up to 300°F is shown in Figure 7, and for 400°F tests in Figure 8.

During compression tests strain was measured with a Baldwin SR1E resistance wire strain gage type compressometer. This is also a strain averaging instrument, and was used over a 2 inch gage length. For tests at room temperature the compressometer was attached directly to specimen edges by spring loaded knife edges. For elevated temperature tests, a set of extension arms were used which gripped the specimen edges in a similar fashion and extended outside the furnace. The SR1E was actuated by the relative motion of the extension arms, unmagnified by any lever system. The elevated temperature compression test assembly is shown in Figure 10.

Load-strain curves were obtained on the Instron machine X-Y recorder. Load was recorded on the Y axis as measured by the test machine SR-4 load cell. Strain was recorded on the X axis either from the extensometer differential transformer signal or the compressometer signal after conversion by an SR-4 converter.

Hardness Tester

A Rockwell hardness tester, Wilson model 4JR was used with 1/16 inch diameter and 1/8 inch diameter indenters to obtain Rockwell B and H scale hardness readings. Hardness test accuracy was periodically checked by hardness tests on calibrated test blocks.

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TABLE I

SINGLE EXPOSURE CONDITIONS TESTED

EXPOSURE CONDITIONS					FINAL TEST TEMPERATURE	
θ_{17} Exposure $\times 10^{-3}$	Temp. °F	Time hrs	Stress (tensile) ksi	Target Strain %	Tension °F	Compression °F
12.92	300	1	0	0	R.T.,300	R.T.,300
12.92	300	1	50	1.0	R.T.,300	R.T.,300
13.49	250	100	0	0	R.T.,300,400	R.T.,300,400
13.49	250	100	35-36	0.1	R.T.,300,400	R.T.,300
13.49	250	100	[illegible]	1.0	R.T.,300,400	R.T.,300
14.44	300	100	0	0	R.T.,200,300,400	R.T.,300
14.44	300	100	20	0.1	R.T., 300	R.T.
14.44	300	100	32	0.3	R.T.,200,300,400	R.T.
14.44	300	100	34-35	1.0	R.T.,200,300,400	R.T.,300
14.58	350	10	0	0	R.T.,300	R.T.,200,300,400
14.58	350	10	20	0.1	R.T.,300	R.T.,300
14.58	350	10	29	0.3	R.T.,300	R.T.,300
14.58	350	10	30-32	1.0	R.T.,300	R.T.,300,400
14.89	350	24	0	0	R.T.,300	
14.89	350	24	24	0.3	R.T.,300	
14.89	350	24	27	1.0	R.T.,300	
15.31	350	80	0	0	R.T.,300	R.T.,300
15.31	350	80	13	0.1	R.T.,300	R.T.,300
15.31	350	80	19	0.3	R.T.,300	R.T.,300
15.31	350	80	21	1.0	R.T.,300	R.T.,300
15.48	400	10	0	0	R.T.,200,300,400	R.T.,200,300,400
15.48	400	10	13	0.1	R.T.,200,300,400	R.T.,300
15.48	400	10	17	0.3	R.T.,200,300,400	R.T.,300
15.48	400	10	19-20	1.0	R.T.,200,300,400	R.T.,300,400
16.38	450	10	0	0	R.T.,200,300,400	R.T.,200,300,400
16.38	450	10	10	0.1		R.T.
16.38	450	10	13	1.0	R.T.,200,300	R.T.,300
17.28	500	10	0	0	R.T.,300	R.T.,200,300,400
17.28	500	10	9	1.0	R.T.,300	R.T.,300
18.98	600	8	0	0	R.T.,200,300,400	
			(Compressive)			
14.59	375	3	0	0	R.T.	R.T.
14.59	375	3	28	-0.3		R.T.

TABLE II

SEQUENTIAL EXPOSURE CONDITIONS TESTED -- STRESSED EXPOSURE[1]

Sequence		Exposure Conditions						Final Test Temperatures	
Code	Description	Total θ_1 Exposure $x10^{-3}$	Step No.	Temp. °F	Time hrs	Stress (tensile) ksi	Target Strain	Tension °F	Compression °F
A-1	Decreasing temp. trend,	•	1	350	3.5	31.0	•		
	high stress	•	2	315	20	32.5	•		
		14.6	3	275	100	35.0	1.0	R.T.,300,400	R.T.,300
A-2	Same as A-1 sequence except lower exposure stresses.						0.25	R.T.,300,400	R.T.,300
A'-1	Inverse of A-1.	•	1	275	100	34.5	•		
	Increasing temp. trend,	•	2	315	20	32.5	•		
	high stress	14.6	3	350	3.5	31.5	1.0	R.T.	
A'-2	Same as A'-1 sequence except lower exposure stresses.						0.25	R.T.	
B-12	Two steps of B-14	•	1	300	100	29.5	•		
		15.0	2	350	24	21.0	0.50	R.T.,300,400	
B-13	Three steps of B-14	•	1	300	100	29.5	•		
	Increasing temp. trend.	•	2	350	24	21.0	•		
		15.3	3	400	3.5	19.0	0.75	R.T.,300,400	R.T.,300
B'-13	Inverse of B-13	•	1	400	3.5	21.0	•		
	Decreasing temp. trend.	•	2	350	24	20.0	•		
		15.3	3	300	100	19.0	0.75	R.T.,300	
B-14	Mixed temp. trend,	•	1	300	100	29.5	•		
	high stress	•	2	350	24	21.0	•		
		•	3	400	3.5	19.0	•		
		15.4	4	350	24	20.0	1.0	R.T.,300,400	R.T.,300
B-24	Same as B-14 sequence except lower exposure stresses.						0.25	R.T.,300	R.T.
B-13a	Modified B-13	•	1	300	100	29.5	•		
	zero-stress last step	•	2	350	24	22.0	•		
		15.3	3	400	3.5	0	0.50	R.T.	
B-14a	Modified B-14	•	1	300	100	29.5	•		
	zero-stress last step	•	2	350	24	21.0	•		
		•	3	400	3.5	19.0	•		
		15.4	4	350	24	0	0.75	R.T.,300	R.T.
D	Zero-stress first step	•	1	350	72	0	•		
	High stress last step	15.3	2	375	3.5	25.0	1.00	R.T.,300	R.T.
E-1	Complex 10 part mixed	•	1	350	10	24.0	•		
	sequence	•	2	325	40	0	•		
		•	3	375	3.5	22.5	•		
		•	4	300	90	24.0	•		
		•	5	350	10	22.0	•		
		•	6	325	40	19.0	•		
		•	7	375	3.5	0	•		
		•	8	300	100	21.5	•		
		•	9	325	40	16.0	•		
		15.4	10	375	3.5	0	0.80	R.T.,300	R.T.
E-2	Same as E-1 sequence except lower exposure stresses						0.25	R.T.	
E-3	Same as E-1 and E-2 sequences except lowest exposure stresses.						0.15	R.T.	

(1) Note: An equivalent unstressed sequential exposure program was provided by zero stress control specimens included with each exposure in this table.

TABLE III

TENSILE AND COMPRESSIVE STRENGTHS -- UNEXPOSED

TENSION											COMPRESSION					
IDENTIFICATION			HARDNESS		PROPERTIES AT TEMPERATURE				CORRECTED PROPERTIES (1)		IDENTIFICATION			PROPERTIES AT TEMPERATURE		CORRECTED PROPERTIES (1)
Nominal Test Temp °F	Test No.	Specimen No.	Rockwell Hardness [illegible]	[illegible]	Actual Test Temp °F	F_{ty} psi	F_{tu} psi	Elong. in 2" %	F_{ty} psi	F_{tu} psi	Nominal Test Temp °F	Test No.	Specimen No.	Actual Test Temp °F	F_{cy} psi	F_{cy} psi
R.T.	71	A1[illegible]			80	67,700	77,900	11.0	68,000	78,100	R.T.	211	C110T(3)	91	73,000	73,300
R.T.	102	A1[illegible](4)			75	67,200	78,500	10.5	67,200	78,500	R.T.	211	C110N	91	72,300	72,600
R.T.	71	A210			75	68,500	78,500	11.5	68,500	78,500	R.T.	211	C110B(2)	91	73,200	73,500
R.T.	71	A211			75	67,900	78,000	11.5	67,900	78,000	R.T	211	C330T	82	75,500	75,700
R.T.	71	A2[illegible]0			80	67,200	77,300	12.0	67,500	77,500	R.T.	211	C330N(2)	82	74,900	75,100
R.T.	71	A2[illegible]0			80	67,200	77,300	10.5	67,500	77,500	R.T.	211	C330B	82	75,400	75,600
R.T.	71	A310			80	67,700	78,100	11.5	68,000	78,300				Average		74,300
R.T.	71	A330			80	67,900	78,600	11.5	68,200	78,800						
R.T.	71	A350			80	67,300	77,400	10.5	67,600	77,500						
R.T.	71	A410			80	67,200	77,800	11.0	67,500	78,000						
R.T.	71	A430			80	67,900	78,600	11.0	68,200	78,800						
R.T.	71	A450			80	67,400	77,400	13.0	67,700	77,600						
R.T.	71	A520			70	69,200	77,800	14.0	69,200	77,800						
R.T.	71	A540			70	68,100	77,000	11.0	68,100	77,000						
R.T.	71	A560			67	70,200	80,600	12.5	70,000	80,500						
R.T.	71	A620			67	69,700	78,600	11.5	69,500	78,500						
R.T.	71	A640			67	65,500	77,600	12.5	65,300	77,500						
R.T.	71	A660			70	70,100	79,300	13.0	70,100	79,300						
R.T.	71	A710			80	68,500	78,900	11.5	68,800	79,100						
R.T.	71	A730			80	68,000	78,700	10.5	68,300	78,900						
R.T.	71	A750			80	67,200	77,100	10.5	67,500	77,300						
R.T.	71	A810			80	68,900	79,700	11.0	69,200	79,900						
R.T.	71	A830			80	69,100	78,700	11.0	69,400	78,900						
R.T.	71	A850			80	67,600	77,900	11.5	67,900	78,100						
R.T.	71	A920			75	67,700	77,400	11.5	67,700	77,400						
R.T.	71	A940			75	65,800	76,700	11.5	65,800	76,700						
R.T.	71	A941			75	67,500	78,100	10.5	67,500	78,100						
R.T.	71	A960			75	68,000	78,900	10.5	68,000	78,900						
R.T.	71	A1020			75	67,100	77,700	10.0	67,100	77,700						
R.T.	71	A1060			75	68,400	79,300	10.0	68,400	79,300						
R.T.	71	A1110			80	68,800	78,300	12.5	69,100	78,500						
R.T.	71	A1130			80	69,100	78,300	10.5	69,400	78,500						
R.T.	71	A1150			80	68,400	77,900	11.5	68,700	78,100						
R.T.	71	A1210			80	68,700	78,200	10.5	69,000	78,400						
R.T.	71	A1230			80	69,100	78,600	12.0	69,400	78,800						
R.T.	102	A1266(4)			75	70,800	77,700	10.7	70,800	77,700						
							Average		68,300	78,300						
R.T.	120	B131	115.5	80.0	74	66,800	75,600	10.5	66,800	75,600						
R.T.	120	B150	116.0	80.0	74	67,600	77,100	11.0	67,600	77,100						
R.T.	102	B166 (4)			77	71,200	81,100	11.5	71,200	81,100						
R.T.	120	B320	116.0	81.0	74	66,500	76,200	11.0	66,500	76,200						
R.T.	120	B360	117.0	83.0	74	67,000	76,700	10.5	67,000	76,700						
R.T.	102	B1266 (4)			77	72,900	80,500	11.0	72,900	80,500						
							Average		67,000	76,400						
R.T.	158	C117			73	68,300	76,300	14.0	68,300	76,300						
R.T.	211	C210 (5)			91	68,000			68,600							
R.T.	211	C331 (5)			82	68,200	76,300	13.5	68,500	76,600						
R.T.	158	C636			73	67,900	75,100	12.5	67,900	75,100						
							Average		68,400	76,100						
200	71	A355			206	64,500	69,200	12.5	64,800	69,700	200	223	C725-1	202	69,100	69,200
200	71	A431			200	65,000	69,700	13.0	65,000	69,700	200	223	C725-2	202	72,500	72,600
200	71	A820			200	65,100	70,400	12.0	65,100	70,400	200	223	C725-3	203	71,700	71,800
							Average		65,000	69,900	200	223	C725-10	203	60,000	69,100
														Average		70,700
300	71	A130			298	57,600	58,900	14.0	57,400	58,700	300	223	C725-4	300	63,700	63,700
300	71	A256			302	56,700	57,600	20.0	56,900	57,800	300	223	C725-5	300	63,600	63,600
300	72	A720			298	56,900	58,500	21.0	56,700	58,300	300	223	C725-6	300	62,000	62,000
							Average		57,000	58,300				Average		63,100
300	120	B230			299	54,300	56,400	18.5	54,200	56,300						
300	120	B420			299	54,400	56,100	18.0	54,300	56,000						
300	120	B460			300	54,600	56,300	11.5	54,600	56,300						
							Average		54,400	56,200						
300	224	C721T			300	56,500	58,300	16.5	56,500	58,300						
300	224	C721B			302	55,900	57,500	19.0	56,200	57,800						
							Average		56,400	58,100						
400	71	A237 (3)			405	41,800	43,000	14.0	42,300	43,400	400	223	C725-7(3)	400	47,200	47,200
400	71	A266 (3)			398	44,000	45,000	13.5	43,700	44,800	400	223	C725-8(3)	400	46,500	46,500
400	71	A610 (3)			397	42,200	43,300	15.5	41,900	43,100	400	223	C725-9(3)	400	48,700	48,700
							Average		42,000	43,600				Average		47,500
400	224	B212 (3)			401	42,700	43,600	13.5	42,800	43,700						
400	224	B425 (3)			401	42,700	44,400	16.5	42,800	44,500						
400	224	B461 (3)			401	42,400	44,400	13.5	42,500	44,500						
							Average		42,700	44,300						
400	224	C722T (3)			402	43,200	44,300	16.0	43,500	44,400						
400	224	C722B (3)			399	42,800	44,200	14.0	42,700	44,100						
							Average		43,100	44,300						

(1) Properties corrected to nominal test temperature.
(2) Specimens refrigerated prior to test.
(3) Strain rates were 0.008 to 0.009 in/in/min for tests at 400°F; 0.013 in/in/min for spec. C110T.
(4) Strengths omitted from average, sheet acceptance tests taken from sheet corners.
(5) Tensile test performed on a creep specimen. (See Figure 2)

TABLE IV

ROOM TEMP. TENSILE STRENGTH AFTER SINGLE EXPOSURES

NOMINAL EXPOSURE CONDITIONS					ACTUAL EXPOSURE CONDITIONS					PROPERTIES AFTER EXPOSURE						CORRECTED PROPERTIES(1)		STRENGTH RATIO			
Temp. °F	Time hr	θ_{17} $T°_R(17+\log_{10}t_{hr})$ x10⁻³	Stress ksi	Total Strain %	Specimen No.	Temp. °F	Time hr	Total Strain %	Specimen Group No.	Rockwell Hardness R_H	Rockwell Hardness R_B	Actual Test Temp. °F	F_{ty} psi	F_{tu} psi	elong in 2in. %	F_{ty} psi	F_{tu} psi	R_T Yield	Ult	$R_?$ Yield	[illegible]
300	1	12.92	0	0	A1216	300	1	0	54	117.0	80.0	78	67,100	77,000	12.0	67,200	77,100	0.974	0.983		
300	1	12.92	0	0	A1214	300	1	0	54			72	67,00	77,300	12.5	67,000	77,300	0.971	0.986		
300	1	12.92	50.0	1.00	A1213	300	1	1.70	54			72	70,800	77,400	10.0	70,800	77,400			1.055	1.[illegible]
300	1	12.92	50.0	1.00	A1111	300	1	1.50	54			75	69,900	76,900	11.0	69,900	76,900			1.042	[illegible]
300	1	12.92	50.0	1.00	A1215	300	1	1.30	54			79	70,500	77,000	11.5	70,600	77,100			1.052	[illegible]
250	100	13.49	0	0	A734	250	100	0	29	115.5	82.0	77	68,000	77,600	11.5	68,100	77,700	0.997	0.985		
250	100	13.49	0	0	A836	249	100	0	30	116.0	81.0	76	68,300	78,700	11.0	68,400	78,700	0.986	0.997		
250	100	13.49	35.0	0.10	A735	248	100	0.09	30			76	66,700	77,600	9.0	66,800	77,700			0.975	0.99[illegible]
250	100	13.49	35.0	0.10	A736	249	100	0.13	30			76	67,300	77,800	9.0	67,400	78,000			0.984	1.00[illegible]
250	100	13.49	47.3	1.00	A731	248	100	1.02	29			77	67,800	76,500	11.0	67,900	76,700			0.991	0.98[illegible]
250	100	13.49	47.3	1.00	A732	248	100	0.80	29			77	67,300	77,200	11.5	67,400	77 400			0.984	0.995
300	100	14.44	0	0	A734	302	100	0	35	115.0	76.0	72	60,400	72,100		60,900	72,600	0.893	0.927		
300	100	14.44	0	0	A811	298	100	0	35			72	61,100	72,600	10.5	60,600	72,100	0.876	0.902		
300	100	14.44	0	0	A724	299	100	0	37	115.0	76.0	72	61,400	73,500		61,100	73,200	0.892	0.927		
300	100	14.44	20.0	0.10	A231	300	100	0 13	35			72	59,900	71,200		59,900	71,200			0.983	0.981
300	100	14.44	20.0	0.10	A232	303	100	0.12	35	115.0	76.0	72	58,300	71,300		59,000	72,000			0.969	0.002
300	100	14.44	20.0	0.10	A233	304	100	0.15	35	115.0	76.0	72	60,500	71,300		61,400	72,200			1.008	0.994
300	100	14.44	20.0	0.10	A715	297	100	0.095	31			74	61,200	72,700		60,500	72,000			0.995	0.992
300	100	14.44	20.0	0.10	A716	300	100	0.082	31			74	60,500	72,000		60,500	72,000			0.995	0.992
300	100	14.44	20.0	0.10	A812	300	100	0.085	31			74	60,500	72,000		60,500	72,000			0.998	0.997
300	100	14.44	32.0	0.35	A341	300	100	0.50	59			80	57,000	67,500	9.0	57,100	67,700			0.938	0.933
300	100	14.44	32.0	0.35	A342	298	100	0.40	59	115.0	75.0	80	57,400	68,800	9.0	56,900	68,500			0.934	0.943
300	100	14.44	32.0	0.35	A343	296	100	0.30	59	115.0	75.0	80	60,100	71,300	9.0	59,200	70,900			0.927	0.9[illegible]
300	100	14.44	35.0	1.00	A721	300	100	1.37	37			75	56,100	68,200		56,100	68,200			0.920	0.939
300	100	14.44	35.0	1.00	A722	298	100	0.72	37			75	57,800	68,900		57,400	68,500			0.941	0.9[illegible]
300	100	14.44	35.0	1.00	A723	301	100	0.99	37	115.0	74.5	75	56,000	66,500		56,300	68,800			0.923	0.947

(1) Properties corrected to nominal exposure conditions and nominal test temperature.

TABLE IV (Continued)

ROOM TEMP. TENSILE STRENGTH AFTER SINGLE EXPOSURES

NOMINAL EXPOSURE CONDITIONS					ACTUAL EXPOSURE CONDITIONS					PROPERTIES AFTER EXPOSURE						CORRECTED PROPERTIES (1)		STRENGTH RATIOS			
Temp. °F	Time hr	θ_{17} T(17+log t) x10^{-3}	Stress ksi	Total Strain %	Specimen No.	Temp. °F	Time hr	Total Strain %	Specimen Group No.	Rockwell Hardness R_H	Rockwell Hardness R_B	Actual Test Temp. °F	F_{ty} psi	F_{tu} psi	elong in 2in. %	F_{ty} psi	F_{tu} psi	Yield	Ult	Yield	Ult
350	10	14.58	0	0	A246	348	10	0	65	115.0	75.0	76	57,900	69,300	10.0	57,300	69,000	[illegible]	[illegible]		
350	10	14.58	0	0	A925	352	10	0	60	115.0	73.5	72	56,900	68,400	12.0	57,400	68,800	[illegible]	[illegible]		
350	10	14.58	0	0	A926	352	10	0	61	115.0	75.0	72	58,300	68,500	11.0	58,800	68,900	[illegible]	[illegible]		
350	10	14.58	20.0	0.10	A914	352	10	0.10	61			72	55,700	67,400	9.0	56,200	67,800			0.972	[illegible]
350	10	14.58	20.0	0.10	A915	350	10	0.10	61			72	56,000	67,600	10.5	56,000	67,800			[illegible]	[illegible]
350	10	14.58	20.0	0.10	A916	351	10	0.10	61			72	56,200	68,000	10.0	56,500	68,200			0.917	[illegible]
350	10	14.58	29.0	0.35	A616	350	10	0.35	60			72	54,900	67,400	10.5	54,900	67,400			[illegible]	[illegible]
350	10	14.58	29.0	0.35	A625	352	10	0.35	60			72	54,900	67,000	10.0	55,400	67,200			[illegible]	[illegible]
350	10	14.58	29.0	0.35	A626	350	10	0.35	60			72	53,600	66,200	10.0	53,600	66,400			[illegible]	[illegible]
350	10	14.58	31.5	1.00	A243	348	10	0.70	65			76	54,000	65,700	9.5	53,600	65,300			0.927	[illegible]
350	10	14.58	31.5	1.00	A244	347	10	0.70	65			76	54,400	66,200	10.0	53,800	65,700			[illegible]	[illegible]
350	10	14.58	31.5	1.00	A245	346	10	0.50	65			76	55,900	67,300	10.0	54,900	66,700			[illegible]	[illegible]
350	24	14.89	0	0	A657	350	24	0	121	113.0	65.0	78	49,000	62,400	10.5	49,000	62,400	0.714	[illegible]		
350	24	14.89	0	0	B133	350	24	0	121	114.0	69.5	78	52,100	64,200	10.5	52,100	64,200	[illegible]	[illegible]		
350	24	14.89	0	0	A847	347	24	0	123	114.0	69.7	78	50,600	63,300	10.5	49,700	62,800	0.717	[illegible]		
350	24	14.89	0	0	B134	347	24	0	123	114.0	70.0	78	52,400	64,500	10.5	51,500	64,000	[illegible]	[illegible]		
350	24	14.89	24.0	0.35	A755	352	24	0.40	121			78	46,300	60,100	9.5	46,800	60,700			0.955	[illegible]
350	24	14.89	24.0	0.35	B132	350	24	0.25	121			78	48,400	62,100	10.5	48,500	62,300			0.930	[illegible]
350	24	14.89	24.0	0.35	A756	351	24	0.35	121			78	47,600	61,400	10.5	48,000	61,900			0.972	[illegible]
350	24	14.89	27.0	1.00	B135	347	24	0.65	123	113.3	67.0	78	48,400	62,100	10.0	47,600	61,600			0.925	[illegible]
350	24	14.89	27.0	1.00	A838	347	24	1.10	123	123.3	64.0	78	46,100	59,500	11.0	45,300	59,000			0.911	[illegible]
350	80	15.31	0	0	A564	354	80	0	63	112.0	63.0	71	40,600	56,700	9.0	41,400	57,500	0.593	0.714		
350	80	15.31	0	0	A565	354	80	0	63	110.0	64.0	71	40,900	57,700	9.5	41,700	58,500	0.596	0.727		
350	80	15.31	0	0	A653	353	80	0	79	110.5	60.0	74	38,600	52,800	10.5	39,200	53,400	0.581	0.685		
350	80	15.31	13.0	0.10	A650	355	80	0.10	79			74	37,600	52,400	10.0	38,700	53,500			0.987	1.002
350	80	15.31	13.0	0.10	A651	353	80	0.10	79			74	37,600	52,200	10.0	38,300	52,800			0.977	0.969
350	80	15.31	13.0	0.10	A652	353	80	0.10	79			74	37,900	53,100	11.0	38,600	53,700			0.985	1.006
350	80	15.31	19.0	0.35	A654	350	80	0.45	80			74	36,300	51,300	11.0	36,300	51,300			0.923	0.951
350	80	15.31	19.0	0.35	A655	354	80	0.55	80			74	35,600	50,100	10.0	36,500	51,000			0.931	0.955
350	80	15.31	19.0	0.35	A656	353	80	0.40	80			74	36,300	51,300	10.5	37,000	51,900			0.944	0.972
350	80	15.31	20.9	1.00	A561	350	80	0.80	63	111.0	59.5	71	37,900	54,400	9.0	37,900	54,400			0.912	0.938
350	80	15.31	21.0	1.00	A562	352	80	1.20	63			71	36,400	52,900	9.0	36,800	53,200			0.886	0.917
350	80	15.31	21.0	1.00	A563	352	80	0.95	63			71	35,700	52,900	9.0	36,100	53,200			0.859	0.917

TABLE IV (Continued)

ROOM TEMP. TENSILE STRENGTH AFTER SINGLE EXPOSURES

NOMINAL EXPOSURE CONDITIONS					ACTUAL EXPOSURE CONDITIONS					PROPERTIES AFTER EXPOSURE						CORRECTED PROPERTIES (1)		STRENGTH RATIOS			
Temp.	Time	θ_{17} T(17+log t) x10^{-3}	Stress	Total Strain	Specimen No.	Temp.	Time	Total Strain	Specimen Group No.	Rockwell Hardness		Actual Test Temp.	F_{ty}	F_{tu}	elong in 2in.	F_{ty}	F_{tu}	R_T		$R_?$	
°F	hr		ksi	%		°F	hr	%		R_H	R_E	°F	psi	psi	%	psi	psi	Yield	Ult	Yield	Ult
400	10	15.48	0	0	A153	400	10	0	16	111.0	62.0	75	39,500	55,200	10.0	39,500	55,200	0.585	[illegible]		
400	10	15.48	0	0	A154	403	10	0	17	111.0	62.0	75	38,700	55,600	10.0	39,400	56,200	0.584	[illegible]		
400	10	15.48	0	0	A354	406	10	0	47	110.0	53.0	77	37,500	53,200	10.0	38,900	54,600	[illegible]	[illegible]		
400	10	15.48	13.0	0.10	A261	398	10	0.09	34			75	38,300	54,800	10.0	38,100	54,600			[illegible]	[illegible]
400	10	15.48	13.0	0.10	A262	400	10	0.07	34			75	37,500	54,100	10.0	37,500	54,100			0.955	[illegible]
400	10	15.48	13.0	0.10	A263	400	10	0.07	34			75	38,000	54,700	9.5	38,000	54,700			[illegible]	[illegible]
400	10	15.48	17.5	0.35	A351	400	10	0.16	47	110.0	54.0	77	37,200	53,000	10.0	37,200	53,200			[illegible]	[illegible]
400	10	15.48	17.5	0.35	A352	400	10	0.19	47	111.0	51.0	77	36,900	53,200	10.0	35,900	53,400			[illegible]	[illegible]
400	10	15.48	17.5	0.35	A353	400	10	0.18	47			77	37,000	52,900	10.0	37,000	53,100			[illegible]	[illegible]
400	10	15.48	20.0	1.00	A151	400	10	0.68	16			75	36,300	51,900	10.0	36,300	51,900			[illegible]	[illegible]
400	10	15.48	20.0	1.00	A152	400	10	1.20	17			75	33,700	49,000	10.0	33,700	[illegible]			[illegible]	[illegible]
400	10	15.48	20.0	1.00	A161	400	10	0.74	26	109.5	59.5	75	36,200	52,400		36,200	[illegible]			0.922	[illegible]
450	10	16.38	0	0	B141	451	10	0	235			84	25,700	43,800	10.0	25,800	[illegible]	0.385	[illegible]		
450	10	16.38	0	0	B322	451	10	0	235			84	26,000	44,200	11.5	26,100	44,700	0.390	[illegible]		
450	10	16.38	0	0	B652	451	10	0	235			84	26,000	43,600	11.0	26,100	44,300	0.390	0.580		
450	10	16.38	0	0	A314	449	10	0	229	104.5	37.5	84	25,600	43,100	10.0	25,600	43,400	[illegible]	[illegible]		
450	10	16.38	0	0	A315	449	10	0	229	104.5	37.0	84	25,300	43,300	11.5	25,300	43,600	0.372	0.557		
450	10	16.38	12.5	1.00	A311	[illegible]	10	0.51	229			84	24,800	42,900	11.0	24,800	43,200			[illegible]	[illegible]
450	10	16.38	12.5	1.00	A312	449	10	0.57	229			84	24,400	42,700	11.5	24,400	43,000			0.959	[illegible]
450	10	16.38	12.5	1.00	A313	451	10	0.52	229			84	24,800	42,400	11.0	24,900	42,900			[illegible]	[illegible]
450	10	16.38	13.0	1.00	A952	450	10	0.51	32	85.0		76	25,700	43,700	11.0	25,700	43,700			[illegible]	[illegible]
450	10	16.38	13.0	1.00	A954	452	10	0.54	32			76	25,200	43,100	11.0	25,300	43,300			0.979	[illegible]
450	10	16.38	13.0	1.00	A1051	453	10	15.50	32			77	23,400	39,800	8.0	23,600	40,200			0.914	[illegible]
500	10	17.28	0	0	A413	503	10	0	33	100.5	74.5	78	19,200	38,400		19,300	38,400	[illegible]	[illegible]		
500	10	17.28	0	0	A415	502	10	0	33	100.5	71.0	78	19,000	38,300		19,100	38,500	0.283	[illegible]		
500	10	17.28	8.7	1.00	A412	497	10	0.37	33	101.0	72.0	78	19,800	38,600	11.0	19,700	38,600			[illegible]	[illegible]
500	10	17.28	8.7	1.00	A414	498	10	0.54	33			78	18,500	38,100	12.5	18,400	38,100			[illegible]	[illegible]
500	10	17.28	8.7	1.00	A416	497	10	0.67	33	100.0	69.5	78	18,500	37,800	12.5	18,400	37,800			[illegible]	[illegible]
600	8	18.98	0	0	A316	600	8	0	230	95.0		84	15,500	37,000	16.5	15,500	37,000	0.228	[illegible]		
600	8	18.98	0	0	B620	600	8	0	230	95.5		84	15,200	36,700	18.0	15,200	[illegible]	0.227	[illegible]		
600	8	18.98	0	0	B621	600	8	0	230	95.5		84	15,200	36,800	16.5	15,200	[illegible]	[illegible]	[illegible]		

TABLE V

200°F TENSILE STRENGTH AFTER SINGLE EXPOSURES

NOMINAL EXPOSURE CONDITIONS					ACTUAL EXPOSURE CONDITIONS					PROPERTIES AFTER EXPOSURE				CORRECTED PROPERTIES (1)		STRENGTH RATIOS			
Temp.	Time	θ_{17} T(17+log t) x10^{-3}	Stress	Total Strain	Specimen No.	Temp.	Time	Total Strain	Specimen Group No.	Actual Test Temp.	F_{ty}	F_{tu}	elong in 2in.	F_{ty}	F_{tu}	R_T Yield	R_T Ult	R_c Yield	R_c Ult
°F	hr		ksi	%		°F	hr	%		°F	psi	psi	%	psi	psi				
300	100	14.44	0	0	A435	302	100	0	83	200	57,700	62,000	11.5	58,300	62,200	0.855	0.789		
300	100	14.44	0	0	A436	302	100	0	83	200	57,400	62,100	11.5	58,000	62,300	0.650	0.792		
300	100	14.44	0	0	A517	302	100	0	95	203	58,000	63,000	11.0	58,700	63,400	0.648	0.815		
300	100	14.44	32.0	0.35	A514	301	100	0.45	95	203	56,200	60,500	12.5	56,600	60,800			0.970	0.971
300	100	14.44	32.0	0.35	A515	302	100	0.60	95	203	53,400	59,600	12.0	54,200	60,000			0.929	0.958
300	100	14.44	32.0	0.35	A516	302	100	0.40	95	203	54,700	60,300	11.5	55,500	60,700			0.951	0.969
300	100	14.44	35.0	1.00	A432	300	100	1.45	83	203	51,600	56,000	9.0	51,700	56,200			0.884	0.897
300	100	14.44	35.0	1.00	A433	301	100	3.00	83	201	51,400	55,600	8.5	51,800	55,800			0.888	[illegible]
300	100	14.44	35.0	1.00	A434	300	100	2.95	83	200	50,800	55,500	12.0	51,800	56,000			0.888	[illegible]
400	10	15.48	0	0	A1254	401	10	0	81	203	37,000	45,100	16.0	37,200	45,500	0.542	0.575		
400	10	15.48	0	0	A1165	399	10	0	76	201	39,800	48,600	20.0	39,700	48,500	0.578	0.621		
400	10	15.48	0	0	A1166	399	10	0	76	199		48,800	16.0		48,600		0.623		
400	10	15.48	0	0	A537	402	10	0	132	200	36,100	45,300	15.5	36,400	45,600	0.530	0.590		
400	10	15.48	13.0	0.10	A1251	402	10	—	81	200	43,400	44,300	16.0	43,700	44,600			1.174	0.982
400	10	15.48	13.0	0.10	A1252	400	10	—	81	203	35,400	44,700	17.0	35,500	44,900			0.954	0.995
400	10	15.48	13.0	0.10	A1253	402	10	0.10	81	204	35,400	44,000	16.5	35,900	44,400			0.965	0.985
400	10	15.48	17.5	0.35	A535	403	10	0.30	132	202	34,200	44,000	16.0	34,800	44,700			0.955	0.980
400	10	15.48	17.5	0.35	A536	403	10	0.30	132	200	35,200	44,800	10.5	35,700	45,300			0.981	0.993
400	10	15.48	17.5	0.35	A526	400	10	0.30	132	200	35,700	45,200	15.5	35,700	45,200			0.981	0.991
400	10	15.48	20.0	1.00	A1162	398	10	0.70	76	204	35,900	46,000	17.5	35,700	45,900			0.899	0.945
400	10	15.48	20.0	1.00	A1163	399	10	0.75	76	204	37,100	45,200	13.5	37,000	46,300			0.932	0.954
400	10	15.48	20.0	1.00	A1164	398	10	0.75	76	202	36,400	45,900	14.0	36,100	45,700			0.909	0.941
450	10	16.38	0	0	A950	449	10	0	74	204	24,500	37,900	15.0	24,500	38,100	0.353	0.490		
450	10	16.38	0	0	A1050	449	10	0	74	203	24,600	37,700	16.5	24,600	37,800	0.360	0.485		
450	10	16.38	13.0	1.00	A1054	451	10	1.25	74	204	23,200	36,800	16.0	23,300	37,100			0.949	0.978
450	10	16.38	13.0	1.00	A1055	449	10	1.25	74	203	23,400	37,000	16.0	23,400	37,100			0.953	0.979
450	10	16.38	13.0	1.00	A1056	451	10	1.85	74	200	23,000	36,800	13.5	23,000	36,800			0.937	0.970
600	8	18.98	0	0	A320	600	8	0	231	202	15,300	36,600	15.0	15,300	36,600	0.225	0.465		
600	8	18.98	0	0	B622	600	8	0	231	200	15,200	36,300	15.5	15,200	36,300	0.227	0.475		
600	8	18.98	0	0	B623	600	8	0	231	201	15,000	36,400	16.0	15,000	36,400	0.224	0.475		

(1) Properties corrected to nominal exposure conditions and nominal test temperature.

TABLE VI

300°F TENSILE STRENGTH AFTER SINGLE EXPOSURE

NOMINAL EXPOSURE CONDITIONS					ACTUAL EXPOSURE CONDITIONS					PROPERTIES AFTER EXPOSURE				CORRECTED PROPERTIES(1)		STRENGTH RATIOS			
Temp. °F	Time hr	θ_{17} T(17+log t) x10^{-3}	Stress ksi	Total Strain %	Specimen No.	Temp. °F	Time hr	Total Strain %	Specimen Group No.	Actual Test Temp. °F	F_{ty} psi	F_{tu} psi	elong. in 2in. %	F_{ty} psi	F_{tu} psi	k_σ Yield	Ult.	k_ϵ Yield	Ult.
300	1	12.92	0	0	A1013	299	1	0	82	302	56,000	58,500	20.0	56,200	58,700	0.838	[illegible]		
300	1	12.92	0	0	A1014	299	1	0	82	302	55,400	57,700	21.5	[illegible]	57,900	0.829	[illegible]		
300	1	12.92	50.0	1.00	A1010	299	1	1.20	82	301	59,000	59,000	[illegible]	59,100	59,100			[illegible]	[illegible]
300	1	12.92	50.0	1.00	A1011	298	1	1.10	82	302	58,800	58,800	17.0	59,000	59,900			[illegible]	[illegible]
300	1	12.92	50.0	1.00	A1012	302	1	1.65	82	301	59,000	59,000	17.5	59,200	59,200			[illegible]	[illegible]
250	100	13.49	0	0	A740	251	100	0	52	300	56,000	57,100	13.0	56,000	57,100	0.825	[illegible]		
250	100	13.49	0	0	A840	251	100	0	52	300	55,100	57,500	17.0	55,100	57,500	0.810	[illegible]		
250	100	13.49	35.0	0.10	A644	251	100	0.15	52	303	56,800	58,000	17.5	57,100	58,300			[illegible]	[illegible]
250	100	13.49	35.0	0.10	A645	251	100	0.15	52	301	56,800	57,800	19.5	56,900	57,900			[illegible]	[illegible]
250	100	13.49	35.0	0.10	A646	253	100	0.15	52	299	55,600	55,900	18.0	55,600	55,900			[illegible]	[illegible]
250	100	13.49	47.3	1.00	A841	250	100	1.10	45	299	54,300	56,200	17.5	54,200	56,100			[illegible]	[illegible]
250	100	13.49	47.3	1.00	A842	250	100	1.11	45	300	54,400	56,000	19.5	54,400	56,000			[illegible]	[illegible]
250	100	13.49	47.3	1.00	A843	250	100	1.00	45	299	54,400	55,900	16.5	54,300	55,800			[illegible]	[illegible]
300	100	14.44	0	0	A345	301	100	0	75	302	51,600	52,100	[illegible]	51,900	52,400	[illegible]	[illegible]		
300	100	14.44	0	0	A513	302	100	0	94	301	51,300	52,600	9.0	51,700	52,900	[illegible]	[illegible]		
300	100	14.44	0	0	A333	300	100	0	75	302	51,800	52,800	19.0	52,000	52,900	[illegible]	[illegible]		
300	100	14.44	20.0	0.10	A510	302	100	0.05	94	300	51,300	52,400	[illegible]	[illegible]	52,700			[illegible]	[illegible]
300	100	14.44	20.0	0.10	A511	302	100	0.05	94	300	47,500	48,500	16.5	[illegible]	48,900			[illegible]	[illegible]
300	100	14.44	20.0	0.10	A512	302	100	0	94	299	47,900	48,700	[illegible]	48,000	48,800			[illegible]	[illegible]
300	100	14.44	32.0	0.35	A335	300	100	0.50	75	302	48,800	49,400	15.0	49,000	49,500			[illegible]	[illegible]
300	100	14.44	32.0	0.35	A336	301	100	0.60	75	302	48,200	48,600	13.5	48,500	49,100			[illegible]	[illegible]
300	100	14.44	32.0	0.35	A344	301	100	0.50	75	302	48,700	49,200	16.0	49,000	49,500			[illegible]	[illegible]
300	100	14.44	35.0	1.00	A134	300	100	0.95	72	299	47,900	48,400	17.0	47,800	48,300			[illegible]	[illegible]
300	100	14.44	35.0	1.00	A141	300	100	1.70	72	300	- - -	46,500	13.5		46,500			- - -	[illegible]
300	100	14.44	35.0	1.00	A142	299	100	1.05	72	299	47,700	48,000	23.0	47,500	47,800			[illegible]	[illegible]
350	10	14.58	0	0	A1015	352	10	0	66	300	48,400	49,000	13.5	[illegible]	49,200	0.724	[illegible]		
350	10	14.58	0	0	A922	350	10	0	87	300	47,400	47,700	17.5	47,400	47,700	0.700	[illegible]		
350	10	14.58	0	0	A912	352	10	0	86	300	48,200	49,000	13.0	48,400	49,200	0.699	[illegible]		
350	10	14.58	20.0	0.10	A921	349	10	0.10	87	300	46,800	47,300	16.0	46,700	47,200	[illegible]	[illegible]
350	10	14.58	20.0	0.10	A923	350	10	0.10	87	300	46,600	46,900	14.5	46,600	46,900			0.968	[illegible]
350	10	14.58	20.0	0.10	A924	350	10	0.10	87	300	45,700	46,500	16.5	45,700	46,500			0.949	[illegible]
350	10	14.58	29.0	0.35	A935	351	10	0.35	117	302	47,600	47,900	17.0	47,700	48,100			0.991	[illegible]
350	10	14.58	29.0	0.35	A937	351	10	0.45	117	300	46,700	46,800	11.0	46,800	46,900			0.972	[illegible]
350	10	14.58	29.0	0.35	A947	351	10	0.40	117	300	47,000	47,300	10.5	47,100	47,300			0.978	0.971
350	10	14.58	31.5	1.00	A910	354	10	1.80	86	298	44,500	44,700	14.0	44,900	45,000			0.933	0.924
350	10	14.58	31.5	1.00	A911	351	10	2.05	86	300	43,600	43,600	12.0	43,700	43,700			0.908	0.897
350	10	14.58	31.5	1.00	A913	351	10	1.50	86	300	44,300	44,600	15.5	44,400	44,700			0.922	0.918

(1) Properties corrected to nominal exposure conditions and nominal test temperature.

TABLE VI (Continued)
300°F TENSILE STRENGTH AFTER SINGLE EXPOSURE

[illegible] EXPOSURE CONDITIONS Temp. °F	Time hr	θ T(17+log t) x10⁻³	Stress ksi	Total Strain %	ACTUAL EXPOSURE CONDITIONS Specimen No.	Temp. °F	Time hr	Total Strain %	Specimen Group No.	PROPERTIES AFTER EXPOSURE Actual Test Temp. °F	F_{ty} psi	F_{tu} psi	elong. in 2 in. %	CORRECTED PROPERTIES (1) F_{ty} psi	F_{tu} psi	STRENGTH RATIO RT Yield	RT Ult.	[illegible] Yield	[illegible] Ult.
350	24	14.89	0	0	A760	350	24	0	122	299	44,900	46,300	12.5	44,800	46,200	0.665	[illegible]		
350	24	14.89	0	0	B232	350	24	0	122	300	44,300	45,100	13.5	44,300	45,100	[illegible]	[illegible]		
350	24	14.89	0	0	A857	351	24	0	124	301	43,300	44,300	16.5	43,500	44,500	[illegible]	[illegible]		
350	24	14.89	0	0	B233	351	24	0	124	300	43,500	44,600	17.5	43,700	44,800	[illegible]	[illegible]		
350	24	14.89	24.0	0.35	A[illegible]1	348	24	0.25	122	300	43,500	44,700	16.0	43,100	44,400			[illegible]	[illegible]
350	24	14.89	24.0	0.35	B231	350	24	0.35	122	300	41,400	42,500	16.0	41,400	42,500			[illegible]	[illegible]
350	24	14.89	24.0	0.35	A8[illegible]	350	24	0.25	122	300	42,500	43,600	17.5	42,500	43,600			[illegible]	[illegible]
350	24	14.89	27.0	1.00	A855	350	24	1.00	124	300	40,200	41,000	14.0	40,200	41,000			[illegible]	[illegible]
350	24	14.89	27.0	1.00	B23[illegible]	350	24	1.75	124	300	38,700	39,500	12.0	38,700	39,500			[illegible]	[illegible]
350	24	14.89	27.0	1.00	A85[illegible]	349	24	0.90	124	301	40,900	41,500	11.0	40,800	41,400			[illegible]	[illegible]
350	80	15.31	0	0	A56[illegible]	352	80	0	88	300	34,900	36,600	22.0	35,200	36,900	0.503	[illegible]		
350	80	15.31	0	0	A565	352	80	0	88	301	35,500	36,600	23.0	35,900	36,900	0.513	[illegible]		
350	80	15.31	0	0	A754	351	80	0	89	297	35,600	36,900	21.5	35,600	36,800	0.527	[illegible]		
350	80	15.31	13.0	0.10	A751	350	80	0.10	89	300	36,100	37,500	20.5	36,100	37,500			[illegible]	[illegible]
350	80	15.31	13.0	0.10	A752	351	80	0.10	89	301	35,000	36,100	25.0	35,200	36,200			[illegible]	[illegible]
350	80	15.31	13.0	0.10	A753	350	80	0.10	89	301	35,300	36,400	24.0	35,400	36,500			[illegible]	[illegible]
350	80	15.31	19.0	0.35	A541	348	80	0.30	98	302	34,100	35,700	18.5	33,900	35,600			[illegible]	[illegible]
350	80	15.31	19.0	0.35	A542	349	80	0.35	98	302	34,000	35,600	16.5	33,900	35,600			[illegible]	[illegible]
350	80	15.31	19.0	0.35	A543	349	80	0.30	98	302	34,800	36,000	23.5	34,700	36,000			[illegible]	[illegible]
350	80	15.31	21.0	1.00	A561	352	80	0.90	88	301	32,600	34,400	16.0	33,000	34,700			[illegible]	[illegible]
350	80	15.31	21.0	1.00	A562	351	80	1.15	88	302	31,900	34,200	23.0	32,200	34,500			[illegible]	[illegible]
350	80	15.31	22.0	1.00	A563	350	80	0.85	88	300	32,300	34,200	17.0	32,300	34,200			[illegible]	[illegible]
400	10	15.48	0	0	A455	401	10	0	78	302	34,100	35,400	20.5	34,400	35,700	0.508	[illegible]		
400	10	15.48	0	0	A456	401	10	0	78	300	33,400	35,300	20.5	33,500	35,400	0.495	[illegible]		
400	10	15.48	0	0	A452	401	10	0	78	302	34,100	35,400	17.0	34,400	35,700	0.508	[illegible]		
400	10	15.48	13.0	0.10	A461	401	10	0.10	70	300	33,900	35,400	25.0	34,100	35,500			1.000	[illegible]
400	10	15.48	13.0	0.10	A462	400	10	0.10	70	299	33,800	35,400	19.0	33,700	35,300			[illegible]	[illegible]
400	10	15.48	13.0	0.10	A463	402	10	0.10	70	299	33,300	35,100	21.5	33,500	35,200			0.982	0.989
400	10	15.48	17.5	0.35	A451	399	10	0.30	78	300	32,800	34,300	16.5	32,700	34,200			0.959	[illegible]
400	10	15.48	17.5	0.35	A453	399	10	0.30	78	302	32,500	34,100	19.5	32,400	34,100			[illegible]	[illegible]
400	10	15.48	17.5	0.35	A454	400	10	0.35	78	302	32,500	34,100	19.0	32,600	34,200			[illegible]	[illegible]
400	10	15.48	20.0	1.00	A360	400	10	0.85	69	299	31,500	33,400	23.0	31,400	33,300			0.921	[illegible]
400	10	15.48	20.0	1.00	A460	401	10	1.10	69	302	31,500	33,100	19.5	31,800	33,400			0.933	0.938
400	10	15.48	20.0	1.00	A464	399	10	0.90	69	300	31,900	33,500	24.0	31,700	33,400			0.930	[illegible]

TABLE VI (Continued)

$300^{\circ}F$ TENSILE STRENGTH AFTER SINGLE EXPOSURE

NOMINAL EXPOSURE CONDITIONS					ACTUAL EXPOSURE CONDITIONS					PROPERTIES AFTER EXPOSURE				CORRECTED PROPERTIES (1)		STRENGTH RATIOS			
Temp. °F	Time hr	θ_{17} T(17+log t) $x10^{-3}$	Stress ksi	Total Strain %	Specimen No.	Temp. °F	Time hr	Total Strain %	Specimen Group No.	Actual Test Temp. °F	F_{ty} psi	F_{tu} psi	elong. in 2in. %	F_{ty} psi	F_{tu} psi	R Yield	Ult.	R Yield	Ult.
450	10	16.38	0	0	B112	451	10	0	238	300	24,600	28,600	30.5	24,600	28,600	[illegible]	[illegible]		
450	10	16.38	0	0	B323	451	10	0	238	300	24,200	28,500	34.0	24,200	28,500	[illegible]	[illegible]		
450	10	16.38	0	0	B653	451	10	0	238	300	24,400	28,500	32.0	24,400	28,500	[illegible]	[illegible]		
450	10	16.38	0	0	A1064	448	10	0	73	302	24,700	28,500	30.5	24,700	28,500	0.352	[illegible]		
450	10	16.38	0	0	A1065	446	10	0	73	300	24,500	28,400	31.5	24,200	28,200	0.354	[illegible]		
450	10	16.38	15.00	1.00	A1062	447	10	0.85	73	300	23,700	27,900	27.0	23,600	27,800	[illegible]	[illegible]		
500	10	17.28	0	0	A212	498	10	0	104	299	18,700	25,400	33.0	18,700	25,300	[illegible]	0.325		
500	10	17.28	0	0	A216	498	10	0	104	300	18,800	25,400	34.5	18,800	25,400	[illegible]	[illegible]		
500	10	17.28	0	0	A110	498	10	0	104	300	18.500	25,400	31.5	18,500	25,400	[illegible]	[illegible]		
500	10	17.28	8.70	1.00	A213	496	10	0.90	104	298	17,900	25,400	38.0	17,800	25,300			[illegible]	[illegible]
500	10	17.28	8.70	1.00	A214	497	10	1.00	104	301	17,700	24,700	35.5	17,600	24,700			[illegible]	[illegible]
500	10	17.28	8.70	1.00	A215	495	10	0.95	104	300	17,700	24,900	36.0	17,700	24,900			[illegible]	[illegible]
600	8	18.98	[illegible]	0	A325	600	8	0	232	302	14,900	27,400	37.5	14,900	27,400	0.219	[illegible]		
600	8	18.98	[illegible]	0	B624	600	8	0	232	302	14,800	27,000	36.5	14,800	27,000	0.221	0.353		
600	8	18.98	[illegible]	0	B625	600	8	0	232	301	14,300	26,800	37.5	14,300	26,800	0.213	[illegible]		

TABLE VII

$400^{\circ}F$ TENSILE STRENGTH AFTER SINGLE EXPOSURES

Nominal Exposure Conditions: Temp. °F	Time hr	G_p T(17+log t) x10^{-3}	Stress ksi	Total Strain %	Actual Exposure Conditions: Specimen No.	Temp. °F	Time hr	Total Strain %	Specimen Group No.	Properties After Exposure: Actual Test Temp. °F	F_{ty} psi	F_{tu} psi	elong in 2in. %	Strain Rate in/in/min	Corrected Properties (1): F_{ty} psi	F_{tu} psi	Strength Ratios: R_e Yield	R_e Ult	Yield	Ult
250	100	13.49	0	0	A933	252	100	0	92	398	41,200	42,900	15.0	0.0090	42,000	42,700	0.607	[illegible]		
250	100	13.49	0	0	A934	252	100	0	92	403	42,100	43,100	15.5	0.0092	42,400	43,400	0.628	[illegible]		
250	100	13.49	0	0	A851	252	100	0	97	400	42,400	43,600	14.5	0.0095	42,400	43,600	0.62[illegible]	[illegible]		
250	100	13.49	35,000	0.10	A852	250	100	0.10	97	400	42,800	43,000	11.0	0.0095	42,800	43,000			[illegible]	[illegible]
250	100	13.49	35,000	0.10	A853	252	100	0.10	97	400	41,900	42,800	17.0	0.0093	41,900	42,800			[illegible]	[illegible]
250	100	13.49	35,000	0.10	A854	251	100	0.10	97	401	42,000	42,800	15.5	0.0100	42,100	42,900			[illegible]	[illegible]
250	100	13.49	47,300	1.00	A930	252	100	1.30	92	402	41,600	41,600	7.5	0.0080	41,800	41,800			[illegible]	[illegible]
250	100	13.49	47,300	1.00	A931	252	100	1.55	92	399	40,700	40,700	5.5	0.0095	40,600	40,600			[illegible]	[illegible]
250	100	13.49	47,300	1.00	A932	252	100	0.90	92	402	42,300	42,400	13.0	0.0080	42,500	42,600			[illegible]	[illegible]
300	100	[illegible]	0	0	A828	303	100	0	94	399	39,400	39,700	11.0	0.0095	39,600	40,100	[illegible]	[illegible]		
300	100	[illegible]	0	0	A447	301	100	0	91	400	38,400	39,300	17.5	0.0090	38,500	39,400	[illegible]	[illegible]		
300	100	[illegible]	0	0	A437	301	100	0	91	399	39,200	39,600	10.0	0.0082	39,200	39,600	[illegible]	[illegible]		
300	100	[illegible]	32,000	0.35	A444	299	100	0.40	91	398	36,500	37,100	23.0	0.0095	36,800	37,300			[illegible]	[illegible]
300	100	[illegible]	32,000	0.35	A445	301	100	0.45	91	400	36,500	36,400	17.0	0.0100	36,600	36,700			[illegible]	[illegible]
300	100	[illegible]	32,000	0.35	A446	301	100	0.20	91	399	36,800	37,100	19.5	0.0095	36,800	37,200			[illegible]	[illegible]
300	100	[illegible]	35,000	1.00	A817	299	100	1.15	94	399	35,500	37,000	15.5	0.0097	35,800	35,800			[illegible]	[illegible]
300	100	[illegible]	35,000	1.00	A627	301	100	[illegible]	96	399	34,800	34,800	6.0	0.0098	34,800	34,800			[illegible]	[illegible]
300	100	[illegible]	35,000	1.00	A817	301	100	[illegible]	94	400	35,300	35,300	7.0	0.0095	36,400	35,400			[illegible]	[illegible]
400	10	15.48	0	0	A428	402	10	0	133	400	27,300	27,700	11.0	0.0093	27,400	27,800	[illegible]	[illegible]		
400	10	15.48	0	0	A166	400	9.8	0	99	400	27,900	26,400	18.5	0.0090	27,900	28,400	[illegible]	[illegible]		
400	10	15.48	0	0	A168	404	10	0	101	400	27,700	27,900	14.0	0.0082	28,100	28,200	[illegible]	[illegible]		
400	10	15.48	13,000	0.10	A465	403	10	0.05	101	396	27,700	27,900	16.0	0.0090	27,800	28,000			[illegible]	[illegible]
400	10	15.48	13,000	0.10	A466	402	10	0.05	101	398	27,400	27,700	17.0	0.0090	27,500	27,900			[illegible]	[illegible]
400	10	15.48	13,000	0.10	A467	402	10	0.10	101	401	27,900	28,000	16.0	0.0087	28,000	28,100			[illegible]	[illegible]
400	10	15.48	17,500	0.35	A417	401	10	0.30	133	400	26,400	26,500	14.0	0.0095	26,500	26,600			[illegible]	[illegible]
400	10	15.48	17,500	0.35	A527	401	10	0.30	133	400	26,700	26,800	14.5	0.0098	26,800	26,900			[illegible]	[illegible]
400	10	15.48	20,000	1.00	A164	401	9.8	1.35	99	398	26,200	26,200	14.0	0.0085	26,200	26,200			[illegible]	[illegible]
400	10	15.48	20,000	1.00	A165	401	9.8	1.00	99	400	26,800	26,800	20.5	0.0081	26,900	26,900			[illegible]	[illegible]
450	10	16.38	0	0	A957	450	10	0	109	400	19,900	20,200	20.5	0.0048	19,900	20,200	[illegible]	[illegible]		
450	10	16.38	0	0	A967	450	10	0	109	400	20,600	20,600	24.0	0.0048	20,600	20,600	[illegible]	[illegible]		
450	10	16.38	0	0	B143	451	10	0	239	402	20,900	21,100	34.5	0.0100	21,000	21,200	[illegible]	[illegible]		
450	10	16.38	0	0	B324	451	10	0	239	400	20,700	21,100	40.0	0.0090	20,700	21,100	[illegible]	[illegible]		
450	10	16.38	0	0	B654	451	10	0	239	400	20,400	21,200	40.0	0.0087	20,400	21,200	[illegible]	[illegible]		

(1) Properties corrected to nominal exposure conditions and nominal test temperature.

TABLE VII (Continued)
400°F TENSILE STRENGTH AFTER SINGLE EXPOSURES

NOMINAL EXPOSURE CONDITIONS					ACTUAL EXPOSURE CONDITIONS					PROPERTIES AFTER EXPOSURE					CORRECTED PROPERTIES (1)		STRENGTH RATIOS			
Temp.	Time	θ_{17} T(17+log T) x10^{-3}	Stress	Total Strain	Specimen No.	Temp.	Time	Total Strain	Specimen Group No.	Actual Test Temp.	F_{ty}	F_{tu}	elong in 2in.	Strain Rate	F_{ty}	F_{tu}	R_T Yield	Ult.	$R_?$ Yield	Ult.
°F	hr		ksi	%		°F	hr	%		°F	psi	psi	%	in/in/min	psi	psi				
600	8	24.98	0	0	A326	600	8	0	233	401	13,700	16,800	53.5	0.011	13,700	13,000	0.201	0.213		
600	8	18.98	0	0	B625	600	8	0	233	401	13,700	16,700	54.5	0.012	13,700	16,700	0.204	0.219		
600	8	15.98	0	0	B627	600	8	0	233	401	13,900	16,900	55.5	0.012	13,900	16,900	0.207	0.221		

TABLE VIII
ROOM TEMP. COMPRESSIVE STRENGTH AFTER SINGLE EXPOSURE

Nominal Exposure Conditions: Temp. °F	Time hr	θ_{17} T(17+log t) x10^{-3}	Stress ksi	Total Strain %	Actual Exposure Conditions: Specimen No.	Temp. °F	Time hr	Total Strain %	Specimen Group No.	Properties After Exposure: Rockwell Hardness R_H	R_B	Actual Test Temp. °F	F_{cy} psi	Corrected Properties(1): F_{cy} psi	Strength Ratios: R_T	R_ϵ
300	1	12.92	0	0	C335T	298	1	0	173	117.0	80.0	75	73,000	73,500	0.989	
300	1	12.92	0	0	C335M	298	1	0	173	116.5	79.5	75	73,300	73,800	0.993	
300	1	12.92	50.0	1.0	C336T	299	1	1.49	173	117.0	80.0	75	71,200	71,500		0.971
300	1	12.92	50.0	1.0	C336M	299	1	1.35	173	116.5	80.5	75	70,700	70,900		0.963
300	1	12.92	50.0	1.0	C336B	301	1	1.60	173	116.5	80.5	75	71,700	71,500		0.971
250	100	13.49	0	0	C232T	253	100	0	168	117.0	82.5	75	75,500	75,500	1.016	
250	100	13.49	0	0	C232M	253	100	0	166	117.0	82.0	75	75,200	75,200	1.012	
250	100	13.49	0	0	C233T	252	100	0	172	117.0	82.5	75	74,800	74,800	1.007	
250	100	13.49	0	0	C233M	251	100	0	172	117.0	82.0	75	75,500	75,500	1.016	
250	100	13.49	0	0	C233B	251	100	0	172	117.0	82.0	75	75,700	75,700	1.019	
250	100	13.49	36.0	0.1	C234T	251	100	0.09	172	117.0	82.0	75	76,700	76,700		1.025
250	100	13.49	36.0	0.1	C234M	251	100	0.13	172	117.0	81.5	75	75,500	75,500		0.999
250	100	13.49	47.3	1.0	C231T	253	100	0.81	168	117.5	80.0	75	72,600	72,600		0.9[illegible]
250	100	13.49	47.3	1.0	C231M	253	100	0.84	168	117.0	80.0	75	72,300	72,300		0.990
250	100	13.49	47.3	1.0	C231B	253	100	0.8[illegible]	168	117.5	81.0	75	73,100	73,100		0.970
300	100	14.44	0	0	C324M	300	100	0	180	116.0	77.0	75	67,300	67,300	0.905	
300	100	14.44	0	0	C324B	300	100	0	180	116.0	77.0	75	68,900	68,900	0.927	
300	100	14.44	0	0	C422B	301	100	0	179	116.0	77.5	75	66,500	67,000	0.902	
300	100	14.44	0	0	C423B	301	100	0	179	116.0	77.0	75	67,300	67,800	0.913	
300	100	14.44	0	0	C326T	302	100	0	164	116.0	77.0	75	66,400	66,900	0.900	
300	100	14.44	0	0	C326M	302	100	0	164	116.0	75.5	75	65,600	66,300	0.892	
300	100	14.44	20.0	0.1	C323T	300	100	0.03	180	116.0	74.5	75	67,800	67,800		0.995
300	100	14.44	20.0	0.1	C323M	300	100	0.03	180	115.5	76.0	75	66,800	66,800		0.982
300	100	14.44	20.0	0.1	C323B	300	100	0.02	180	116.0	76.0	75	67,500	67,500		0.993
300	100	14.44	32.0	0.35	C321T	301	100	0.41	179	115.5	74.5	75	62,900	63,200		0.938
300	100	14.44	32.0	0.35	C321M	301	100	0.37	179	115.5	75.5	75	63,300	63,600		0.9[illegible]
300	100	14.44	32.0	0.35	C321B	301	100	0.34	179	115.5	75.0	75	63,300	63,600		0.944
300	100	14.44	33.9	1.0	C327T	302	100	0.75	164	115.0	72.5	75	59,700	60,300		0.905
300	100	14.44	33.9	1.0	C327M	301	100	0.75	164	115.5	73.0	75	60,600	60,900		0.914
300	100	14.44	33.9	1.0	C327B	301	100	0.71	164	115.5	74.0	75	65,000	65,300		0.980

(1) Properties corrected to nominal exposure conditions and nominal test temperature.

TABLE VIII (Continued)
ROOM TEMP. COMPRESSIVE STRENGTH AFTER SINGLE EXPOSURE

NOMINAL EXPOSURE CONDITIONS					ACTUAL EXPOSURE CONDITIONS					PROPERTIES AFTER EXPOSURE				CORRECTED PROPERTIES(1), STRENGTH RATIO		
Temp. °F	Time hr	G_{17} T(17+log t) x10⁻³	Stress ksi	Total Strain %	Specimen No.	Temp. °F	Time hr	Total Strain %	Specimen Group No.	Rockwell Hardness R_H	Rockwell Hardness R_B	Actual Test Temp. °F	F_{cy} psi	F_{cy} psi	R_T	R_c
350	10	14.58	0	0	C412T	350	10	0	166	115.0	76.5	75	62,300	62,300	0.8[illegible]	
350	10	14.58	0	0	C412K	350	10	0	166	115.0	75.5	75	61,800	61,800	0.8[illegible]	
350	10	14.58	0	0	C413T	352	10	0	177	106.5	78.5	75	60,300	61,000	0.821	
350	10	14.58	0	0	C413K	352	10	0	177	106.0	78.0	75	59,400	60,100	0.809	
350	10	14.58	0	0	C222B	351	10	0	161	115.0	74.5	75	61,400	61,700	0.830	
350	10	14.58	0	0	C224T	351	10	0	161	115.5	75.5	75	60,300	60,600	0.81[illegible]	
350	10	14.58	20.0	0.1	C411K	350	10	0.07	166	115.0	74.0	75	60,300	60,300		[illegible]
350	10	14.58	20.0	0.1	C411B	350	10	0.09	166	115.0	73.0	75	61,900	61,900		[illegible]
350	10	14.58	29.0	0.35	C414T	352	10	0.31	177	106.0	76.0	75	58,000	58,700		[illegible]
350	10	14.58	29.0	0.35	C414K	352	10	0.28	177	105.5	75.5	75	58,300	59,000		[illegible]
350	10	14.58	29.0	0.35	C414B	351	10	0.34	177	105.5	75.0	75	57,800	58,200		[illegible]
350	10	14.58	30.0	1.0	C223T	350	10	0.77	161	114.5	70.5	75	55,600	55,[illegible]		[illegible]
350	10	14.58	30.0	1.0	C223K	350	10	0.75	161	115.0	70.0	75	55,000	55,000		[illegible]
350	10	14.58	30.0	1.0	C223B	350	10	0.64	161	114.5	71.0	75	56,000	56,000		0.9[illegible]
350	80	15.31	0	0	C314T	351	80	0	169	112.0	63.0	75	44,900	45,100	0.607	
350	80	15.31	0	0	C316B	351	80	0	169	111.5	61.0	75	44,000	44,200	0.595	
350	80	15.31	0	0	C314K	350	80	0	185	112.0	62.5	82	44,700	44,700	0.602	
350	80	15.31	0	0	C314B	350	80	0	185	112.0	61.0	82	44,100	44,100	0.594	
350	80	15.31	0	0	C316T	350	80	0	165	112.5	62.0	75	44,000	44,000	0.592	
350	80	15.31	0	0	C316K	350	80	0	165	112.5	61.5	75	44,000	44,000	0.592	
350	80	15.31	13.0	0.1	C315T	351	80	0.10	169	111.5	60.0	75	44,900	45,100		[illegible]
350	80	15.31	13.0	0.1	C315K	351	80	0.08	169	111.5	58.5	75	44,500	44,700		[illegible]
350	80	15.31	13.0	0.1	C315B	351	80	0.07	169	111.5	58.5	75	43,700	43,900		[illegible]
350	80	15.31	19.0	0.35	C313T *	350	80	0.33	185	110.0	59.5	82	43,700	43,700		[illegible]
350	80	15.31	19.0	0.35	C313K	349	80	0.35	185	111.5	58.5	82	42,500	42,300		[illegible]
350	80	15.31	19.0	0.35	C313B	350	80	0.32	185	111.0	58.5	82	43,400	43,400		[illegible]
350	80	15.31	21.25	1.0	C317T	350	80	0.62	165	111.0	57.0	75	41,200	41,200		[illegible]
350	80	15.31	21.25	1.0	C317K	349	80	0.66	165	111.0	55.0	75	41,000	40,800		0.927
350	80	15.31	21.25	1.0	C317B	349	80	0.70	165	111.0	54.0	75	37,900	37,700		[illegible]
400	10	15.48	0	0	C442T	400	10	0	167	110.5	56.5	75	40,600	40,600	0.543	
400	10	15.48	0	0	C422K	400	10	0	167	111.0	56.0	75	40,800	40,800	0.549	
400	10	15.48	0	0	C423T	400	10	0	178	111.5	59.5	75	40,400	40,400	0.544	
400	10	15.48	0	0	C423K	400	10	0	178	111.0	59.5	75	40,200	40,200	0.541	
400	10	15.48	0	0	C214K	402	10	0	163	110.5	55.0	75	40,000	40,300	0.542	
400	10	15.48	0	0	C214B	402	10	0	163	110.5	55.5	75	39,100	39,400	0.530	

* Strain rate for specimen C313T was 0.0063 in/in/min (rest were 0.007 - 0.011)

ROOM TEMP. COMPRESSIVE STRENGTH AFTER SINGLE EXPOSURE

NOMINAL EXPOSURE CONDITIONS					ACTUAL EXPOSURE CONDITIONS					PROPERTIES AFTER EXPOSURE				CORRECTED PROPERTIES (a)	STRENGTH RATIOS	
Temp. °F	Time hr	θ = T(17+log t) x10⁻³	Stress ksi	Total Strain %	Specimen No.	Temp. °F	Time hr	Total Strain %	Specimen Group No.	Rockwell Hardness R_H	Rockwell Hardness R_B	Actual Test Temp. °F	F_{cy} psi	F_{cy} psi	R_T	R_c
400	10	15.48	13.0	0.1	C421T	401	10	0.11	167	110.0	53.0	75	40,900	41,100		[illegible]
400	10	15.48	13.0	0.1	C421M	400	10	0.07	167	111.0	53.0	75	40,300	40,300		0.990
400	10	15.48	13.0	0.1	C421B	400	10	0.09	167	110.0	54.0	75	40,900	40,900		[illegible]
400	10	15.48	17.5	0.35	C424T	401	10	0.26	178	110.0	55.0	75	38,700	38,900		[illegible]
400	10	15.48	17.5	0.35	C424M	400	10	0.24	178	110.5	55.5	75	39,000	39,000		[illegible]
400	10	15.48	17.5	0.35	C424B	400	10	0.22	178	111.0	56.0	75	39,100	39,100		[illegible]
400	10	15.48	19.35	1.0	C215T	402	10	0.60	163	109.5	53.0	75	38,200	38,500		[illegible]
400	10	15.48	19.35	1.0	C215M	401	10	0.76	163	109.0	49.5	75	37,100	37,300		[illegible]
400	10	15.48	19.35	1.0	C215B	402	10	0.95	163	109.0	49.0	75	36,100	36,400		[illegible]
450	10	16.38	0	0	C124T	450	10	0	184	105.5	34.0	81	27,900	27,900	0.376	
450	10	16.38	0	0	C126T	451	10	0	171	105.5	37.0	75	28,200	28,300	0.381	
450	10	16.38	0	0	C126M	451	10	0	171	105.5	38.0	75	28,200	28,300	0.381	
450	10	16.38	0	0	C126B	452	10	0	171	105.5	39.0	75	28,600	28,700	0.386	
450	10	16.38	10.5	0.1	C125T	450	10	0.14	184	104.5	34.5	81	28,800	28,800		[illegible]
450	10	16.38	10.5	0.1	C125M	450	10	0.13	184	105.0	34.0	81	29,200	29,200		[illegible]
450	10	16.38	10.5	0.1	C125B	450	10	0.12	184	104.5	33.0	81	28,400	28,400		1.016
450	10	16.38	13.0	1.0	C127T	451	10	1.04	171	104.0	29.0	75	26,100	26,200		0.922
450	10	16.38	13.0	1.0	C127M	450	10	0.87	171	104.5	29.0	75	27,400	27,400		0.964
450	10	16.38	13.0	1.0	C127B	451	10	0.68	171	104.5	34.0	75	26,800	26,900		[illegible]
500	10	17.28	0	0	C616T	501	10	0	174	98.5		75	20,600	20,600	0.277	
500	10	17.28	0	0	C616M	501	10	0	174	98.5		75	21,000	21,000	0.283	
500	10	17.28	8.70	1.0	C617T	502	10	1.15	174	98.5		75	19,400	19,400		0.933
500	10	17.28	8.70	1.0	C617M	501	10	1.22	174	98.0		75	19,200	19,200		0.923
500	10	17.28	8.70	1.0	C617B	500	10	1.24	174	98.0		75	19,300	19,300		0.928
COMPRESSION EXPOSURE STRESS CHECK TEST:																
377	3	14.63	0	0	C610T	377	3	0	216			90	59,000	59,400	0.800	
377	3	14.63	0	0	C510M	378	3	0	216			90	59,100	59,600	0.802	
377	3	14.63	0	0	C610B	378	3	0	216			90	57,500	57,900	0.780	
377	3	14.63	28.5	-0.3	C610M	376	3	-0.32	216			90	56,300	56,100		0.950
377	3	14.63	28.5	-0.3	C510T	376	3	-0.26	216			90	58,900	58,900		1.000
377	3	14.63	28.5	-0.3	C510B	376	3	-0.26	216			90	57,800	57,800		0.980

TABLE IX
200°F COMPRESSIVE STRENGTH AFTER SINGLE EXPOSURES

NOMINAL EXPOSURE CONDITIONS					ACTUAL EXPOSURE CONDITIONS					PROPERTIES AFTER EXPOSURE		CORRECTED PROPERTIES (1)	STRENGTH RATIOS	
Temp. °F	Time hr	$\theta_{.7}$ T(17+log t) x10^{-3}	Stress ksi	Total Strain %	Specimen No.	Temp. °F	Time hr	Total Strain %	Specimen Group No.	Actual Test Temp. °F	F_{cy} psi	F_{cy} psi	R_T	R_E
350	10	14.58	0	0	C113T	352	10	0	215	202	60,900	61,500	0.828	
350	10	14.58	0	0	C113M	352	10	0	215	201	58,900	59,500	0.801	
350	10	14.58	0	0	C113B	352	10	0	215	202	56,400	57,000	0.767	
400	10	15.48	0	0	C116T	400	10	0	214	200	40,900	40,900	0.550	
400	10	15.48	0	0	C116M	400	10	0	214	200	41,200	41,200	0.555	
400	10	15.48	0	0	C116B	400	10	0	214	200	40,400	40,400	0.543	
450	10	16.38	0	0	C533T	451	10	0	236	200	27,600	27,600	0.371	
450	10	16.38	0	0	C533M	451	10	0	236	200	27,500	27,500	0.370	
450	10	16.38	0	0	C533B	451	10	0	236	200	27,000	27,000	0.363	
500	10	17.28	0	0	C626M	501	10	0	222	201	23,700	23,700	0.319	
500	10	17.28	0	0	C626B	501	10	0	222	203	21,700	21,700	0.292	

(1) Properties corrected to nominal exposure conditions and nominal test temperature.

TABLE X
300°F COMPRESSIVE STRENGTH AFTER SINGLE EXPOSURE

NOMINAL EXPOSURE CONDITIONS					ACTUAL EXPOSURE CONDITIONS					PROPERTIES AFTER EXPOSURE		CORRECTED PROPERTIES (1)	STRENGTH RATIOS	
Temp. °F	Time hr	G_{17} T(17+log t) x10⁻³	Stress ksi	Total Strain %	Specimen No.	Temp. °F	Time hr	Total Strain %	Specimen Group No.	Actual Test Temp. °F	F_{cy} psi	F_{cy} psi	R_T	R_E
300	1	12.92	0	0	C310B	299	1	0	228	300	61,100	61,100	0.822	
300	1	12.92	0	0	C616B	299	1	0	228	302	60,900	61,100	0.822	
300	1	12.92	50.0	1.00	C516T	300	1	0.86	228	300	59,200	59,200		[illegible]
300	1	12.92	50.0	1.00	C516M	300	1	1.24	228	301	57,400	57,500		[illegible]
300	1	12.92	50.0	1.00	C516B	300	1	2.01	228	300	57,400	57,400		[illegible]
250	100	13.49	0	0	C637B	252	100	0	217	301	61,300	[illegible],400	[illegible]	
250	100	13.49	0	0	C437B	252	100	0	217	301	62,100	[illegible],200	[illegible]	
250	100	13.49	0	0	C232B	250	100	0	192	299	61,300	[illegible],200	0.824	
250	100	13.49	0	0	C236B	250	100	0	192	299	62,600	[illegible],500	0.841	
250	100	13.49	0	0	C632T	250	100	0	240	302	59,400	[illegible],600	0.802	
250	100	13.49	0	0	C632M	250	100	0	240	300	60,400	[illegible],400	0.812	
250	100	13.49	36.0	0.10	C631T	251	100	0.14	240	302	59,000	59,200		[illegible]
250	100	13.49	36.0	0.10	C631M	250	100	0.13	240	302	60,300	60,500		1.008
250	100	13.49	36.0	0.10	C631B	250	100	0.09	240	301	60,400	60,500		1.008
250	100	13.49	47.3	1.0	C535T	252	100	0.94	217	300	58,100	58,100		0.940
250	100	13.49	47.3	1.0	C535M	252	100	0.89	217	301	58,900	59,000		0.955
250	100	13.49	47.3	1.0	C535B	252	100	0.91	217	300	57,000	57,000		0.922
300	100	14.44	0	0	C625M	301	100	0	218	301	55,800	56,100	0.755	
300	100	14.44	0	0	C625B	301	100	0	218	301	56,300	56,600	0.762	
300	100	14.44	35.0	1.00	C624T	302	100	1.33	218	300	49,400	49,700		0.882
300	100	14.44	35.0	1.00	C624M	301	100	1.27	218	300	49,000	49,100		0.871
300	100	14.44	35.0	1.00	C624B	301	100	1.20	218	299	47,300	47,400		0.841

(1) Properties corrected to nominal exposure conditions and nominal test temperatures.

TABLE X (Continued)

300°F COMPRESSIVE STRENGTH AFTER SINGLE EXPOSURE

Nominal Exposure Conditions: Temp. °F	Time hr	θ_{17} T(17+log t) x10^{-3}	Stress ksi	Total Strain %	Actual Exposure Conditions: Specimen No.	Temp. °F	Time hr	Total Strain %	Specimen Group No.	Properties After Exposure: Actual Test Temp. °F	F_{cy} psi	Corrected Properties(1): F_{cy} psi	Strength Ratios: R_T	R_ϵ
350	10	14.58	0	0	C120M	350	10	0	199	300	55,600	55,600	0.748	
350	10	14.58	0	0	C224M	351	10	0	200	303	54,100	54,500	0.734	
350	10	14.58	0	0	C216M	352	10	0	227	300	52,200	52,800	0.711	
350	10	14.58	0	0	C216B	352	10	0	227	299	50,800	51,300	0.690	
350	10	14.58	0	0	C413B	351	10	0	201	302	55,100	55,500	0.747	
350	10	14.58	20.0	0.10	C416T	351	10	0.13	201	299	53,400	53,500		0.984
350	10	14.58	20.0	0.10	C416M	350	10	0.09	201	300	53,700	53,700		0.987
350	10	14.58	20.0	0.10	C416B	351	10	0.09	201	303	51,400	51,900		0.954
350	10	14.58	29.0	0.35	C417T	352	10	0.31	227	300	49,500	50,100		0.963
350	10	14.58	29.0	0.35	C417M	351	10	0.42	227	300	49,800	50,200		0.964
350	10	14.58	29.0	0.35	C417B	352	10	0.37	227	300	49,200	49,700		0.955
350	10	14.58	31.5	1.00	C121T	351	10	1.38	199	300	44,600	44,900		0.825
350	10	14.58	31.5	1.00	C121M	349	10	0.75	199	298	50,500	50,000		0.919
350	10	14.58	31.5	1.00	C121B	348	10	0.73	199	302	50,300	50,000		0.919
350	80	15.31	0	0	C622B	350	80	0	219	300	38,200	38,200	0.514	
350	80	15.31	0	0	C310T	350	80	0	196	302	37,700	37,800	0.509	
350	80	15.31	0	0	C310M	351	80	0	197	303	36,900	37,200	0.501	
350	80	15.31	13.0	0.10	C410T	350	80	0.05	197	300	37,500	37,500		0.994
350	80	15.31	13.0	0.10	C410M	350	80	0.05	197	300	37,100	37,100		0.983
350	80	15.31	13.0	0.10	C410B	350	80	0.06	197	303	37,500	37,700		0.999
350	80	15.31	19.0	0.35	C311T	350	80	0.35	196	300	37,800	37,800		1.002
350	80	15.31	19.0	0.35	C311M	350	80	0.27	196	300	36,500	36,500		0.967
350	80	15.31	19.0	0.35	C311B	350	80	0.27	196	301	36,900	37,000		0.981
350	80	15.31	21.5	1.00	C623M	350	80	0.79	219	304	34,500	34,600		0.917
350	80	15.31	21.5	1.00	C623B	350	80	0.71	219	300	35,600	35,600		0.944
400	10	15.48	0	0	C120B	400	10	0	202	303	38,700	38,800	0.522	
400	10	15.48	0	0	C427T	400	10	0	203	300	36,200	36,200	0.487	
400	10	15.48	0	0	C427M	400	10	0	203	301	35,300	35,400	0.476	
400	10	15.48	0	0	C427B	400	10	0	204	300	36,500	36,500	0.491	
400	10	15.48	0	0	C527B	400	10	0	204	300	35,700	35,700	0.480	
400	10	15.48	13.0	0.10	C420T	399	10	0.09	204	301	35,400	35,300		0.967
400	10	15.48	13.0	0.10	C420M	399	10	0.17	204	300	35,900	35,700		0.978
400	10	15.48	13.0	0.10	C420B	400	10	0.07	204	299	35,600	35,500		0.973
400	10	15.48	17.5	0.35	C425T	400	10	0.29	203	300	34,700	34,700		0.951
400	10	15.48	17.5	0.35	C426M	399	10	0.29	203	299	34,200	34,000		0.931
400	10	15.48	17.5	0.35	C426B	400	10	0.23	203	300	34,500	34,500		0.945
400	10	15.48	20.0	1.00	C220T	400	10	0.82	202	301	33,200	33,200		0.912
400	10	15.48	20.0	1.00	C220M	399	10	0.59	202	300	34,000	33,800		0.926
400	10	15.48	20.0	1.00	C220B	398	10	0.54	202	300	34,300	34,000		0.941

TABLE X (Continued)

300°F COMPRESSIVE STRENGTH AFTER SINGLE EXPOSURE

NOMINAL EXPOSURE CONDITIONS					ACTUAL EXPOSURE CONDITIONS					PROPERTIES AFTER EXPOSURE		CORRECTED PROPERTIES (1)	STRENGTH RATIOS	
Temp. °F	Time hr	Θ_{17} T(17+log t) X10^{-3}	Stress ksi	Total Strain %	Specimen No.	Temp. °F	Time hr	Total Strain %	Specimen Group No.	Actual Test Temp. °F	F_{cy} psi	F_{cy} psi	R_T	R_ϵ
450	10	16.38	0	0	C123T	450	10	0	205	301	26,300	26,400	0.355	
450	10	16.38	0	0	C123M	450	10	0	205	301	26,100	26,100	0.351	
450	10	16.38	0	0	C123B	450	10	0	205	301	26,400	26,400	0.355	
450	10	16.38	13.0	1.00	C122T	449	10	0.94	205	300	24,400	24,400		0.928
450	10	16.38	13.0	1.00	C122M	448	10	0.62	205	299	24,500	24,400		0.928
450	10	16.38	13.0	1.00	C122B	448	10	0.59	205	301	24,800	24,700		0.939
500	10	17.28	0	0	C630T	499	10	0	242	302	20,000	20,000	0.269	
500	10	17.28	0	0	C630M	499	10	0	242	300	19,300	19,300	0.260	
500	10	17.28	0	0	C614T	498	10	0	206	301	20,300	20,300	0.273	
500	10	17.28	0	0	C614M	498	10	0	206	300	19,500	19,500	0.262	
500	10	17.28	0	0	C614B	498	10	0	206	301	20,300	20,300	0.273	
500	10	17.28	8.7	1.00	C530T	500	10	0.79	242	301	19,200	19,200		0.977
500	10	17.28	8.7	1.00	C530M	498	10	0.74	242	301	19,900	19,900		1.012
500	10	17.28	8.7	1.00	C530B	498	10	0.75	242	301	19,500	19,500		0.992
500	10	17.28	8.7	1.00	C613T	497	10	1.11	206	301	20,200	20,200		1.010
500	10	17.28	8.7	1.00	C613M	498	10	1.08	206	301	20,100	20,100		1.005
500	10	17.28	8.7	1.00	C613B	499	10	1.15	206	302	19,500	19,500		0.975

TABLE XI
400°F COMPRESSIVE STRENGTH AFTER SINGLE EXPOSURE

NOMINAL EXPOSURE CONDITIONS					ACTUAL EXPOSURE CONDITIONS					PROPERTIES AFTER EXPOSURE			CORRECTED PROPERTIES (1)	STRENGTH RATIOS	
Temp. °F	Time hr	θ_{17} T(17+log t) x10^{-3}	Stress ksi	Total Strain %	Specimen No.	Temp. °F	Time hr	Total Strain %	Specimen Group No.	Actual Test Temp. °F	F_{cy} psi	Strain Rate in/in/min	F_{cy} psi	R_T	R_ϵ
250	100	13.49	0	0	C334T	252	100	0	209	400	46,500	0.0085	46,500	0.626	
250	100	13.49	0	0	C334M	251	100	0	209	400	47,500	0.0090	47,500	0.639	
250	100	13.49	0	0	C334B	251	100	0	209	402	48,100	0.0085	48,100	0.647	
350	10	14.58	0	0	C112T	352	10	0	207	398	42,400	0.0065	42,400	0.571	
350	10	14.58	0	0	C112M	352	10	0	207	402	41,000	0.0085	41,300	0.555	
350	10	14.58	0	0	C112B	352	10	0	207	400	40,600	0.0083	40,800	0.549	
350	10	14.58	31.5	1.00	C111T	352	10	0.73	207	400	38,200	0.0075	38,400		0.925
350	10	14.58	31.5	1.00	C111M	351	10	0.96	207	399	36,700	0.0085	36,700		0.884
350	10	14.58	31.5	1.00	C111B	351	10	1.04	207	399	36,600	0.0090	36,600		0.881
400	10	15.48	0	0	C115T	400	10	0	208	400	30,000	0.0067	30,000	0.404	
400	10	15.48	0	0	C115M	400	10	0	208	399	30,300	0.0092	30,200	0.406	
400	10	15.48	0	0	C115B	400	10	0	208	400	29,100	0.0085	29,100	0.392	
400	10	15.48	20.0	1.00	C114T	400	10	0.79	208	400	28,100	0.0090	28,100		0.946
400	10	15.48	20.0	1.00	C114M	399	10	0.81	208	400	27,700	0.0080	27,600		0.929
400	10	15.48	20.0	1.00	C114B	399	10	1.06	208	400	26,300	0.0093	26,200		0.882
450	10	16.38	0	0	C534T	451	10	0	237	400	21,300	0.0075	21,300	0.287	
450	10	16.38	0	0	C534M	451	10	0	237	400	21,800	0.0078	21,800	0.293	
450	10	16.38	0	0	C534B	451	10	0	237	401	21,600	0.0075	21,700	0.292	
500	10	17.28	0	0	C611T	502	10	0	213	402	18,100	0.0085	18,100	0.244	
500	10	17.28	0	0	C611M	501	10	0	213	400	17,400	0.0095	17,400	0.234	
500	10	17.28	0	0	C611B	500	10	0	213	400	17,100	0.0090	17,100	0.230	

(1) Properties corrected to nominal exposure conditions and nominal test temperature.

TABLE XII
ROOM TEMP. TENSILE STRENGTH AFTER SEQUENTIAL EXPOSURES

Sequence Code	Specimen No.	Nominal Exposure Conditions and Resulting Strain * Step 1	Step 2	Step 3	Step 4	Total θ_{17} Exposure X10 -3 (1)	Total Strain %	Specimen Group No.	Properties After Exposures: Rockwell Hardness R_H	Rockwell Hardness R_B	Actual Test Temp. °F	F_{ty} psi	F_{tu} psi	elong. in 2in. %	Corrected Properties (2) F_{ty} psi	F_{tu} psi	Strength Ratios R_7 Yield	R_7 Ult.	R_6 Yield	R_6 Ult.
A-1		350°F 3.5 hr 31.0 ksi	315°F 20 hr 32.5 ksi	275°F 100 hr 35.0 ksi																
	A544	0%	0%	0%		14.57	0	105	115.0	75.0	70	61,000	71,700	9.5	61,000	71,700	0.895	0.932		
	A545	0.15	0.30	0.95		14.58	1.40	105			70	55,100	66,900	9.5	55,100	66,900			0.910	0.933
	A545	0.20	0.25	1.05		14.58	1.50	105			70	55,000	66,700	10.0	55,000	66,700			0.908	0.935
A-2		350°F 3.5 hr 21.0 ksi	315°F 20 hr 22.0 ksi	275°F 100 hr 23.0 ksi																
	A765	0	0	0		14.56	0	116	116.5	80.0	70	59,700	71,300	9.5	59,700	71,300	0.885	0.922		
	A766	0	0	0		14.56	0	116	116.0	79.0	70	60,000	71,600	11.0	60,000	71,600	0.890	0.928		
	A762	-	-	-		14.50	0.07	116			70	59,900	71,200	10.5	59,900	71,200			0.997	0.995
	A763	0.03	0.04	0.02		14.53	0.09	116			70	58,900	70,400	10.0	58,900	70,400			0.981	0.982
	A764	-	-	-		14.53	0.09	116			70	58,400	70,200	10.0	58,400	70,200			0.973	0.981
A'-2		275°F 100 hr 34.5 ksi	315°F 20 hr 32.5 ksi	350°F 3.5 hr 31.5 ksi																
	A1123	0	0	0		14.62	0	115	114.5	74.0	72	55,700	67,800	11.0	55,700	67,800	0.605	0.8[illegible]3		
	A1126	0	0	0		14.59	0	129	116.0	78.0	76	58,300	69,700	11.0	58,400	69,800	0.846	0.891		
	A1221	0	0	0		14.59	0	129	116.0	79.0	76	59,800	70,400	10.0	59,900	70,500	0.866	0.897		
	A1120	0.20	0.25	1.30		14.60	1.75	115			72	51,400	63,600	10.0	51,400	63,600			.922	.940
	A1121	0.20	0.35	2.30		14.62	2.85	115			72	49,400	61,400	8.5	49,400	61,400			.886	.905
	A1122	0.20	0.35	1.35		14.63	1.90	115			72	50,800	62,600	9.0	50,800	62,600			.911	.925
	A1124	0.25	0.45	0.35		14.60	1.05	129			76	52,800	65,200	10.0	52,900	65,300			.895	0.931
	A1125	0.20	0.20	0.35		14.57	0.75	129			76	53,800	66,100	10.0	53,900	66,200			0.912	0.944
	A1220	0.20	0.10	0.15		14.58	0.45	129			76	55,500	67,800	10.5	55,600	67,900			0.941	0.959

* Specimen inelastic strains during each step. These are listed below nominal exposure conditions. (Values derived by subtraction of cumulative strain readings obtained at the end of each step, are only approximate.)

(1) Actual exposure temperatures (± 4°F from nominal) were used to compute θ_{17}.

(2) Corrected to nominal test temperatures.

TABLE XII (Continued)

ROOM TEMP. TENSILE STRENGTH AFTER SEQUENTIAL EXPOSURES

Sequence Code	Specimen No.	NOMINAL EXPOSURE CONDITIONS AND RESULTING STRAIN * Step 1	Step 2	Step 3	Step 4	Total θ₁ Exposure X10⁻³ (1)	Total Strain %	PROPERTIES AFTER EXPOSURE Specimen Group No.	Rockwell Hardness R_H	R_B	Actual Test Temp. °F	F_{ty} psi	F_{tu} psi	elong. in 2 in. %	CORRECTED PROPERTIES (2) F_{ty} psi	F_{tu} psi	[illegible] RATIOS [illegible]	[illegible]	[illegible]	[illegible]
A'-2		275°F 100 hr 29.0 ksi	315°F 20 hr 28.0 ksi	350°F 3.5 hr 25.0 ksi																
	A1225	0%	0%	0%		14.5[illegible]	0	130	115.0	77.0	75	59,800	70,200	11.0	59,900	70,[illegible]	0.8[illegible]	[illegible]		
	A1222	0.10	0.05	0		14.54	0.15	130			75	56,100	68,000	11.5	5[illegible],200	[illegible]8,100			[illegible]	[illegible]
	A1223	0.10	0.05	0		14.53	0.15	130			75	57,200	68,600	10.0	57,300	68,700			[illegible]	[illegible]
	A1224	0.10	0.05	0		14.54	0.15	130			[illegible]	58,500	69,200	11.5	58,500	69,500			[illegible]	[illegible]
B-12		300°F 100 hr 29.5 ksi	350°F 24 hr 21.0 ksi																	
	A1016	0	0			15.03	0	118	112.0	58.0	73	46,600	60,400	10.0	[illegible]	60,400	0.594	[illegible]		
	A1017	0	0			15.03	0	118	113.0	67.5	73	47,000	60,300	11.5	47,000	60,300	0.700	[illegible]		
	A1112	0.25	0.15			15.02	0.40	118			73	43,700	58,100	10.5	43,700	58,100			[illegible]	[illegible]
	A1113	0.30	0.15			15.03	0.45	118			73	42,700	57,100	9.5	42,700	57,100			[illegible]	[illegible]
	A1114	0.25	0.15			15.00	0.40	118			73	43,700	57,900	10.0	43,700	57,900			[illegible]	[illegible]
B-13		300°F 100 hr 29.5 ksi	350°F 24 hr 21.0 ksi	400°F 3.5 hr 19.0 ksi																
	B512	0	0	0		15.25	0	126	112.0	62.0	72	41,700	57,100	11.5	41,700	57,100	0.603	[illegible]		
	B513	0	0	0		15.25	0	126	113.5	64.5	72	41,000	56,400	10.0	41,000	56,400	0.592	0.725		
	B510	0.25	0.15	0.10		15.25	0.50	126			72	38,400	54,200	10.0	38,400	54,200			[illegible]	[illegible]
	B511	0.25	0.10	0.20		15.25	0.55	126			72	38,200	54,000	10.0	38,200	54,000			[illegible]	[illegible]
	B514	0.25	0.05	0.15		15.24	0.45	126			72	38,500	54,200	10.0	38,[illegible]00	54,200			[illegible]	[illegible]
S'-12		400°F 3.5 hr 21.0 ksi	350°F 24 hr 20.0 ksi	300°F 100 hr 19.0 ksi																
	B421	0	0	0		15.27	0	140	112.5	62.5	74	44,000	58,200	9.5	44,000	58,200	.657	[illegible]		
	B422	0	0	0		15.27	0	140	113.0	65.0	74	43,700	58,200	9.5	43,700	58,200	.652	[illegible]		
	B423	0	0	0		15.27	0	140			74	44,000	58,200	10.0	44,000	58,200	.657	.762		
	B424	0.20	0.15	0.10		15.27	0.45	140			74	39,800	55,400	10.5	39,800	55,400			[illegible]	[illegible]
	B526	0.25	0.10	0.10		15.26	0.45	140	111.5	57.5	74	39,800	55,400	10.0	39,800	55,400			[illegible]	[illegible]
	B527	0.25	0.10	0.05		15.23	0.40	140			74	41,100	56,100	10.5	41,100	56,100			[illegible]	[illegible]

TABLE XII (Continued)

ROOM TEMP. TENSILE STRENGTH AFTER SEQUENTIAL EXPOSURES

NOMINAL EXPOSURE CONDITIONS AND RESULTING STRAIN *								PROPERTIES AFTER EXPOSURE								CORRECTED PROPERTIES (2)		STRENGTH RATIOS			
Sequence Code	Specimen No.	Step 1	Step 2	Step 3	Step 4	Total θ_{17} Exposure X10 -3 (1)	Total Strain %	Specimen Group No.	Rockwell Hardness R_H	Rockwell Hardness R_B	Actual Test Temp. °F	F_{ty} psi	F_{tu} psi	elong. in 2in. %	F_{ty} psi	F_{tu} psi	R_F Yield	R_F Ult.	R_C Yield	R_C Ult.
B-14		300°F 100 hr 29.5 ksi	350°F 24 hr 21.0 ksi	400°F 3.5 hr 19.0 ksi	350°F 24 hr 20.0 ksi															
	B442	0%	0%	0%	0%	15.40	0	143	111.0	56.5	72	38,200	53,500	10.0	38,200	53,500	.570	.700		
	B445	0	0	0	0	15.40	0	143	110.0	54.5	72	37,600	53,200	10.0	37,600	53,200	.561	[illegible]		
	B441	0.25	0.20	0.10	0.55	15.39	1.10	143	109.5	51.0	72	34,700	49,700	9.5	34,700	49,700			.916	[illegible]
	B443	0.30	0.15	0.15	0.55	15.38	1.15	143	109.5	50.0	72	34,400	49,700	9.0	34,400	49,700			.908	[illegible]
	B444	0.25	0.10	0.15	0.40	15.38	0.90	143			72	34,900	50,200	9.0	34,900	50,200			.921	[illegible]
B-24		300°F 100 hr 20.0 ksi	350°F 24 hr 19.0 ksi	400°F 3.5 hr 14.0 ksi	350°F 24 hr 14.0 ksi															
	B456	0	0	0	0	15.40	0	154	110.0	58.5	74	38,000	53,000	10.0	38,000	53,000	.567	.695		
	B457	0	0	0	0	15.40	0	154	111.0	58.0	74	37,700	52,900	10.0	37,700	52,900	.563	.692		
	B555	0.07	0.08	0	0.04	15.40	0.19	154			74	36,700	52,400	10.5	36,700	52,400			.970	.984
	B556	0.07	0.07	0.03	0.04	15.40	0.21	154			74	36,700	52,800	10.5	36,700	52,800			.970	.997
	B557	0.08	0.06	0.03	0.04	15.39	0.21	154			74	37,000	52,400	10.0	37,000	52,400			.978	.984
B-13a		300°F 100 hr 29.5 ksi	350°F 24 hr 22.0 ksi	400°F 3.5 hr 0 ksi																
	B520	0	0	0		15.27	0	134	111.5	57.0	73	41,200	56,200	10.0	41,100	56,200	.594	.722		
	B521	0.25	0.25	0		15.30	0.50	134			73	38,000	53,700	10.0	38,000	53,700			.924	.951
	B522	0.25	0.20	0		15.26	0.45	134	110.0	52.5	73	38,600	54,000	9.5	38,600	54,000			.939	.961
	B523	0.25	0.10	0		15.26	0.35	134	110.5	54.0	73	39,200	54,500	9.5	39,100	54,500			.951	[illegible]
B-14a		300°F 100 hr 29.5 ksi	350°F 24 hr 21.0 ksi	400°F 3.5 hr 19.0 ksi	350°F 24 hr 0 ksi															
	B540	0	0	0	0	15.40	0	150	111.0	57.0	72	39,600	54,300	10.0	39,600	54,300	.591	.721		
	B440	0.31	0.21	0.17	0	15.39	0.69	150	110.0	57.5	72	36,500	52,400	10.5	36,400	52,400			.921	.965
	B524	0.26	0.21	0.21	0	15.40	0.68	150			72	35,700	51,900	9.0	36,700	51,900			.927	.955
	B525	0.23	0.17	0.16	0	15.38	0.56	150			72	37,800	52,700	10.0	37,800	52,700			.955	.970

TABLE XII (Continued)
ROOM TEMP. TENSILE STRENGTH AFTER SEQUENTIAL EXPOSURES

Sequence Code	Specimen No.	Nominal Exposure Conditions and Resulting Strain * Step 1	Step 2	Step 3	Step 4	Total θ·7 Exposure X10^{-3} (1)	Total Strain %	Properties After Exposure: Specimen Group No.	Rockwell Hardness R_H	Rockwell Hardness R_B	Actual Test Temp. °F	F_{ty} psi	F_{tu} psi	elong. in 2in. %	Corrected Properties (2): F_{ty} psi	F_{tu} psi	Strength Ratios: R_T Yield	R_T Ult.	R_E Yield	R_E Ult.
D		350°F 70 hr 0 ksi	350°F 3 hr 25.0 ksi																	
	1120	0%	0%			15.31	0	146	112.0	63.0	74	44,200	58,700	0.5	44,100	58,700	.659	.770		
	1126	0	0			15.31	0	146	113.0	62.0	74	44,300	58,900	0.0	44,300	58,900	.660	.771	.961	[illegible]
	1225	0	0.94			15.31	0.96	146			74	42,500	56,700	0.0	42,500	56,700			.946	.962
	1226	0	1.35			15.31	1.35	146			74	41,900	56,500	8.5	41,900	56,500			.944	.961
	1227	0	1.24			15.31	1.24	146			74	42,200	56,500	8.0	42,200	56,500				

TABLE XII (Continued)
ROOM TEMP. TENSILE STRENGTH AFTER SEQUENTIAL EXPOSURES

Sequence Code	Specimen No.	Step 1	Step 2	Step 3	Step 4	Step 5	Step 6	Step 7	Step 8	Step 9	Step 10	Total θ_{17} Exposure X10⁻³ (1)	Total Strain %	Specimen Group No.	Rockwell Hardness R_H	Rockwell Hardness R_E	Actual Test Temp °F	F_{ty} psi	F_{tu} psi	elong. in 2 in. %	Corrected Properties (2) F_{ty} psi	Corrected Properties (2) F_{tu} psi	Strength Ratio [illegible] Yield	Strength Ratio [illegible]	Strength Ratio [illegible] Yield	Strength Ratio [illegible]
		NOMINAL EXPOSURE CONDITIONS AND RESULTING STRAIN *												PROPERTIES AFTER EXPOSURE												
[illegible]		350°F 10 hr [illegible] ksi	325°F 36 hr 0 ksi	375°F 3 hr 22.5 ksi	300°F 90 hr 24.0 ksi	350°F 10 hr 27.0 ksi	325°F 36 hr 19.0 ksi	375°F 3 hr 0 ksi	300°F 100 hr 21.5 ksi	325°F 36 hr 14.0 ksi	375°F 3 hr 0 ksi															
	[illegible]	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	15.40	0	151	110.5	57.0	74	38,800	54,300	10.5	38,800	54,300	0.579	0.7[illegible]		
	[illegible]	0	0	0	0	0	0	0	0	0	0	15.40	0	151	110.5	55.5	74	[illegible]	54,300	11.5	38,[illegible]	54,300	[illegible]	[illegible]		
	[illegible]	0.15	0	0.10	0.10	0.15	0	0	0.22	0.12	0	15.39	0.84	151	108.5	53.0	74	35,700	51,600	11.0	35,700	[illegible]			[illegible]	[illegible]
	[illegible]	0.15	0	0.20	0.05	0.20	0.05	0	0.21	0.09	0	15.39	0.95	151	109.5	51.0	74	35,200	50,800	10.0	35,200	[illegible]			[illegible]	[illegible]
	[illegible]	0.15	0	0.15	0.10	0.10	0.05	0	0.17	0.06	0	15.39	0.78	151	109.0	51.5	74	35,800	52,300	10.0	35,800	[illegible]			[illegible]	[illegible]
[illegible]		350°F 16 hr 19.0 ksi	325°F 36 hr 0 ksi	375°F 3 hr 17.0 ksi	300°F 90 hr 16.0 ksi	350°F 10 hr 18.0 ksi	325°F 36 hr 16.0 ksi	375°F 3 hr 0 ksi	300°F 100 hr 18.0 ksi	325°F 36 hr 15.5 ksi	375°F 3 hr 0 ksi															
	[illegible]	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	15.40	0	157	110.0	59.5	84	41,700	54,600	10.0	41,700	54,800	0.623	0.728		
	[illegible]	0	0	0	0	0	0	0	0	0	0	15.40	0	157	110.5	59.0	84	39,000	54,100	11.0	39,000	54,300	0.593	0.72[illegible]		
	[illegible]	0.07	0	0.04	0.02	0.02	0.02	0	0	0.04	0	15.35	0.27	157	110.0	56.5	84	38,700	53,700	9.0	38,700	53,[illegible]			[illegible]	[illegible]
	[illegible]	0.09	0	0.05	-0.02*	0.03	0.01	0	0.02	0.04	0	15.38	0.22	157	110.5	57.0	84	38,200	53,500	10.0	38,200	53,7[illegible]			[illegible]	[illegible]
	[illegible]	0.05	0	0.04	-0.01*	0.03	0.02	0	0.01	0.03	0	15.38	0.21	157	110.5	59.0	84	39,000	54,100	10.5	39,000	54,300			[illegible]	[illegible]
[illegible]		350°F 16 hr 13.5 ksi	325°F 36 hr 0 ksi	375°F 3 hr 14.0 ksi	300°F 90 hr 15.0 ksi	350°F 10 hr 15.0 ksi	325°F 36 hr 14.0 ksi	375°F 3 hr 0 ksi	300°F 100 hr 15.5 ksi	325°F 36 hr 13.5 ksi	375°F 3 hr 0 ksi															
	[illegible]	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	15.40	[illegible]	155	111.[illegible]	[illegible]	78	38,700	53,800	10.5	38,7[illegible]	53,900	[illegible]	[illegible]		
	[illegible]	0	0	0	0	0	0	0	0	0	0	15.40	0	155	111.[illegible]	59.0	78	38,600	53,800	10.5	38,[illegible]	53,[illegible]	[illegible]	[illegible]		
	[illegible]	0.02	0	0.05	0	0.01	0.01	0	0.09	0.09	0	15.40	0.24	155	110.5	55.0	78	37,7[illegible]	53,400	10.5	37,700	53,[illegible]			[illegible]	[illegible]
	[illegible]	0.04	0	0.05	-0.01*	0.01	0.01	0	0.04	0	0	15.40	0.11	155	110.5	58.0	78	37,700	53,400	10.5	37,700	53,500			[illegible]	[illegible]
	[illegible]	0.02	0	0.06	-0.02*	0.02	0.04	0	-0.02	0.03	0	15.39	0.24	155	110.5	60.0	78	38,300	53,800	10.5	38,300	53,900			[illegible]	[illegible]

TABLE XIII
300°F TENSILE STRENGTH AFTER SEQUENTIAL EXPOSURE

NOMINAL EXPOSURE CONDITIONS AND RESULTING STRAIN *								PROPERTIES AFTER EXPOSURE					CORRECTED PROPERTIES (2)		STRENGTH RATIOS			
Sequence Code	Specimen No.	Step 1	Step 2	Step 3	Step 4	Total θ_{17} Exposure X10^{-3} (1)	Total Strain %	Specimen Group No.	Actual Test Temp. °F	F_{ty} psi	F_{tu} psi	elong. in 2 in. %	F_{ty} psi	F_{tu} psi	R_T Yield	R_T Ult.	R_ϵ Yield	R_ϵ Ult.
A-1		350°F 3.5 hr 31,500 psi	315°F 20 hr 32,500 psi	275°F 100 hr 34,500 psi														
	A1026	0%	0%	0%		14.60	0	110	303	50,200	50,300	11.0	50,500	50,600	0.752	0.551		
	A1023	0.10	0.25	0.50		14.56	0.85	110	302	47,300	47,500	11.0	47,500	47,700			0.941	0.943
	A1024	0.20	0.30	0.60		14.58	1.10	110	302	46,500	46,800	16.0	46,700	47,000			0.925	0.925
	A1025	0.05	0.70	0.30		14.58	1.05	110	303	45,500	45,800	13.5	45,800	46,100			0.907	0.911
A-2		350°F 3.5 hr 27,500 psi	315°F 20 hr 28,000 psi	275°F 100 hr 29,000 psi														
	A864	0	0	0		14.57	0	135	300	50,600	52,400	9.5	50,600	52,400	0.746	0.570		
	A861	0.10	0.05	0.10		14.56	0.25	135	299	48,900	50,800	12.5	48,800	50,700			0.964	0.970
	A862	0.10	0.05	0.10		14.55	0.25	135	300	48,700	50,200	15.0	48,700	50,200			0.962	0.960
	A863	0.10	0.05	0.10		14.58	0.25	135	299	49,700	50,600	9.0	49,600	50,500			0.981	0.965
S-12		300 F 100 hr 29,500 psi	350 F 24 hr 21,000 psi															
	A1134	0	0			14.96	0	119	300	42,100	43,200	18.0	42,100	43,200	0.607	0.550		
	A1135	0	0			14.96	0	119	302	42,400	43,000	13.5	42,600	43,200	0.614	0.550		
	A1131	0.30	0.15			14.97	0.45	119	300	38,700	39,900	17.5	38,700	39,900			0.915	0.944
	A1132	0.30	0.15			14.95	0.45	119	300	39,600	41,200	18.0	39,600	41,200			0.936	0.954
	A1133	0.30	0.10			14.95	0.40	119	300	39,400	41,000	22.0	39,400	41,000			0.931	0.949

* Specimen inelastic strains during each step. These are listed below nominal exposure conditions. (Values derived by subtraction of cumulative strain readings obtained at the end of each step, are only approximate.)

(1) Actual exposure temperatures (± 4°F from nominal) were used to compute θ_{17}.

(2) Corrected to nominal test temperatures.

TABLE XIII (Continued)

300°F TENSILE STRENGTHS AFTER SEQUENTIAL EXPOSURE

Sequence Code	Specimen No.	NOMINAL EXPOSURE CONDITIONS AND RESULTING STRAIN: Step 1	Step 2	Step 3	Step 4	Total θ_{17} Exposure X10 -3 (1)	Total Strain %	PROPERTIES AFTER EXPOSURE: Specimen Group No.	Actual Test Temp. °F	F_{ty} psi	F_{tu} psi	elong. in 2in. %	CORRECTED PROPERTIES (2): F_{ty} psi	F_{tu} psi	STRENGTH RATIOS: RT Yield [illegible]	[illegible]	[illegible] Yield [illegible]	[illegible]
B-13		300°F 100 hr 29,500 psi	350°F 24 hr 21,000 psi	400°F 3.5 hr 19,000 psi														
	B312	0%	0%	0%		15.34	0	144	299	34,900	36,700	20.5	34,900	35,600	0.520	[illegible]		
	B313	0	0	0		15.34	0	144	300	34,600	36,700	22.5	34,600	36,700	[illegible]	0.486		
	B321	0	0	0		15.34	0	144	300	34,700	36,600	20.5	34,700	36,600	0.513	[illegible]		
	B310	0.25	0.16	0.33		15.34	0.74	144	299	32,200	34,000	20.0	32,200	33,900			[illegible]	[illegible]
	B312	0.29	0.05	0.34		15.32	0.68	144	300	32,100	34,000	18.5	32,100	34,000			0.924	[illegible]
	B314	0.24	0.12	0.20		15.29	0.56	144	299	33,500	35,500	18.5	33,500	[illegible]			[illegible]	[illegible]
B'-13		400°F 3.5 hr 21,000 psi	350°F 24 hr 20,000 psi	300°F 100 hr 10,000 psi														
	B325	0	0	0		15.27	0	142	300	36,900	38,200	17.5	36,900	38,200	[illegible]	[illegible]		
	B326	0	0	0		15.27	0	142	300	37,100	38,300	21.0	37,100	38,300	0.555	[illegible]		
	B327	0	0	0		15.27	0	142	300	37,300	38,200	13.5	37,300	38,200	0.557	[illegible]		
	B315	0.25	0.15	0.05		15.28	0.45	142	298	34,900	36,500	12.0	34,700	36,300			0.935	[illegible]
	B316	0.20	0.15	0.05		15.25	0.40	142	300	35,500	36,700	11.5	35,500	36,700			[illegible]	[illegible]
	B317	0.25	0.10	0.05		15.25	0.40	142	300	35,900	37,500	13.5	35,900	37,500			0.958	[illegible]
B-14		300°F 100 hr 29,500 psi	350°F 24 hr 21,000 psi	400°F 3.5 hr 19,000 psi	350°F 24 hr 19,500 psi													
	B446	0	0	0	0	15.35	0	145	300	34,800	36,100	22.0	34,600	36,100	0.520	0.473		
	B545	0	0	0	0	15.35	0	145	300	34,600	35,800	18.0	34,600	35,800	0.515	0.469		
	B447	0.30	0.20	0.15	0.15	15.35	0.80	145	300	31,800	33,300	13.5	31,800	33,300			[illegible]	[illegible]
	B546	0.30	0.20	0.25	0.25	15.35	1.00	145	299	31,600	33,200	17.5	31,600	33,200			0.910	[illegible]
	B547	0.30	0.15	0.15	0.20	15.33	0.80	145	300	32,500	34,100	20.5	32,500	34,100			0.937	[illegible]
B-24		300°F 100 hr 19,000 psi	350°F 24 hr 19,000 psi	400°F 3.5 hr 14,000 psi	350°F 24 hr 14,000 psi													
	B550	0	0	0	0	15.40	0	148	301	34,200	35,500	20.5	34,200	35,600	0.510	0.466		
	B554	0	0	0	0	15.40	0	148	302	33,900	35,300	21.0	33,900	35,300	0.506	0.463		
	B551	0.07	0.10	0.04	0.04	15.37	0.25	148	304	33,500	34,400	17.5	33,600	34,800			[illegible]	0.962
	B552	0.06	0.09	0.05	0.04	15.37	0.24	148	299	32,900	34,700	21.0	32,900	34,600			0.967	[illegible]
	B553	0.07	0.07	0.04	0.04	15.37	0.22	148	300	33,700	35,200	21.0	33,700	35,200			0.990	0.993

TABLE XIII (Continued)

300°F TENSILE STRENGTH AFTER SEQUENTIAL EXPOSURE

Sequence Code	Specimen No.	Step 1	Step 2	Step 3	Step 4	Total Θ_{17} Exposure X10 $^{-3}$ (1)	Total Strain %	Specimen Group No.	Actual Test Temp. °F	F_{ty} psi	F_{tu} psi	elong. in 2 in. %	Corrected F_{ty} psi	Corrected F_{tu} psi	R_T Yield	R_T Ult.	R_ϵ Yield	R_ϵ Ult.
		NOMINAL EXPOSURE CONDITIONS AND RESULTING STRAIN *						PROPERTIES AFTER EXPOSURE					CORRECTED PROPERTIES (2)		STRENGTH RATIOS			
B-14a		300°F 100 hr 29,500 psi	350°F 24 hr 21,000 psi	400°F 3.5 hr 19,000 psi	350°F 24 hr 0 psi													
	B544	0%	0%	0%	0%	15.38	0	149	300	33,900	35,100	17.5	33,900	35,100	0.506	0.460		
	B542	0.23	0.10	0.24	0	15.40	0.57	149	300	32,400	33,800	[illegible]	32,400	33,800			0.95[illegible]	[illegible]
	B542	0.25	0.17	0.25	0	15.39	0.68	149	301	31,900	33,200	22.0	31,900	33,300			0.941	0.949
	B543	0.24	0.18	0.14	0	15.35	0.56	149	300	33,400	34,500	18.5	33,400	34,500			0.985	[illegible]
D		350°F 70 hr 0 psi	375°F 3.0 hr 25,000 psi															
	B223	0	0			15.27	0	156	302	37,500	38,800	18.0	37,600	38,900	0.561	0.510		
	B224	0	0			15.27	0	156	301	37,300	38,600	19.5	37,400	38,700	0.558	0.507		
	B220	0	1.55			15.27	1.55	156	301	36,700	37,300	[illegible]	36,800	37,400			0.982	[illegible]
	B221	0	2.2[illegible]			15.27	2.26	156	301	36,300	37,300	12.5	36,400	37,400			0.971	0.965
	B222	0	1.53			15.27	1.53	156	302	36,500	37,200	13.0	[illegible]	37,300			0.979	[illegible]

TABLE XIII (Continued)

300°F TENSILE STRENGTH AFTER SEQUENTIAL EXPOSURE

		NOMINAL EXPOSURE CONDITIONS AND RESULTING STRAIN *													PROPERTIES AFTER EXPOSURE				CORRECTED (2) PROPERTIES		STRENGTH RATIOS			
Sequence Code	Specimen No.	Step 1	Step 2	Step 3	Step 4	Step 5	Step 6	Step 7	Step 8	Step 9	Step 10	Total θ_{17} Exposure $X10^{-3}$ (1)	Total Strain %	Specimen Group No.	Actual Test Temp. °F	F_{ty} psi	F_{tu} psi	elong. in 2 in. %	F_{ty} psi	F_{tu} psi	[illegible]	[illegible]	[illegible]	[illegible]
E-1		350°F 10 hr 24.0 ksi	325°F 36 hr 0 ksi	375°F 3 hr 22.5 ksi	300°F 90 hr 24.0 ksi	350°F 10 hr 22.0 ksi	325°F 36 hr 19.0 ksi	375°F 3 hr 0 ksi	300°F 100 hr 21.5 ksi	325°F 36 hr 16.0 ksi	375°F 3 hr 0 ksi													
	B344	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	15.39	0	152	301	34,[illegible]	3[illegible]	25.5	34,[illegible]	[illegible],100	[illegible]	[illegible]		
	B345	0	0	0	0	0	0	0	0	0	0	15.39	0	152	301	34,100	35,900	28.0	34,100	35,000	0.509	[illegible]		
	B341	0.15	0	0.20	0.15	0.10	0.05	0	0.14	0.08	0	15.39	0.8[illegible]	152	30[illegible]	32,000	33,[illegible]	14.5	32,000	33,600			[illegible]	[illegible]
	B342	0.15	0	0.10	0.20	0.10	0.05	0	0.13	0.02	0	15.39	0.75	152	301	31,700	33,400	15.5	31,700	33,500			[illegible]	[illegible]
	B343	0.15	0	0.10	0.10	0.10	0	0	0.11	0.04	0	15.38	0.60	152	300	32,400	33,900	16.5	32,400	33,900			[illegible]	[illegible]

TABLE XIV

400°F TENSILE STRENGTH AFTER SEQUENTIAL EXPOSURES

		NOMINAL EXPOSURE CONDITIONS AND RESULTING STRAIN *						PROPERTIES AFTER EXPOSURE						CORRECTED PROPERTIES (2)		STRENGTH RATIOS			
Sequence Code	Specimen No.	Step 1	Step 2	Step 3	Step 4	Total θ_{17} Exposure $\times 10^{-3}$ (1)	Total Strain %	Specimen Group No.	Actual Test Temp. °F	F_{ty} psi	F_{tu} psi	elong. in 2 in. %	Strain Rate in/in/min	F_{ty} psi	F_{tu} psi	R_T Yield	R_T Ult.	R_ϵ Yield	R_ϵ Ult.
A-1		350°F 3.5 hr 31.5 ksi	315°F 20 hr 32.5 ksi	275°F 100 hr 34.5 ksi															
	A1034	0%	0%	0%		14.57	0	113	400	38,600	38,600	7.0	0.0078	38,600	38,500	0.574	0.495		
	A1035	0.10	0.25	0.70		14.55	1.05	113	400	35,500	35,600	10.0	0.0065	35,500	35,600			0.919	0.922
	A1036	0.05	0.25	0.75		14.55	1.05	113	399	36,000	36,100	10.5	0.0065	35,900	36,000			0.930	0.942
	A1037	0	0.25	0.35		14.52	0.60	113	399	37,100	37,100	9.5	0.0067	37,000	37,000			0.959	0.959
A-2		350°F 3.5 hr 27.5 ksi	315°F 20 hr 28.0 ksi	275°F 100 hr 29.0 ksi															
	A936	0	0	0		14.55	0	136	397	38,400	40,000	7.5	0.0093	38,100	39,700	0.563	0.511		
	A944	0.10	0.10	0.05		14.54	0.25	136	402	36,900	38,400	15.0	0.0090	37,100	38,600			0.974	0.972
	A945	0.15	0.10	0		14.55	0.25	136	400	36,400	37,500	9.0	0.0092	36,400	37,500			0.955	0.945
	A946	0.10	0.15	0		14.55	0.25	136	397	35,700	36,600	11.5	0.0090	35,400	36,300			0.929	0.914
B-12		300°F 100 hr 29.5 ksi	350°F 24 hr 21.0 ksi																
	A1232	0	0			14.96	0	127	402	33,200	34,000	11.5	0.0093	33,300	34,100	0.480	0.433		
	A1233	0	0			14.96	0	127	402	33,500	34,200	10.5	0.0096	33,600	34,300	0.484	0.435		
	A1231	0.25	0.10			14.97	0.35	127	401	31,800	32,300	16.0	0.0098	31,900	32,400			0.952	0.947
	A1234	0.20	0.10			14.98	0.30	127	402	31,700	32,200	12.0	0.0097	31,800	32,300			0.949	0.944
	A1235	0.20	0.10			14.96	0.30	127	401	31,700	32,200	12.0	0.0094	31,800	32,300			0.949	0.944

* Specimen inelastic strains during each step. These are listed below nominal exposure conditions. (Values derived by subtraction of cumulative strain readings obtained at the end of each step, are only approximate.)

(1) Actual exposure temperatures (± 4°F from nominal) were used to compute θ_{17}.

(2) Corrected to nominal test temperatures.

(2) Corrected to nominal test temperatures.

TABLE XIV (Continued)
400°F TENSILE STRENGTH AFTER SEQUENTIAL EXPOSURES

Sequence Code	Specimen No.	NOMINAL EXPOSURE CONDITIONS AND RESULTING STRAIN * Step 1	Step 2	Step 3	Step 4	Total Ω_{17} Exposure $\times 10^{-3}$ (1)	Total Strain %	PROPERTIES AFTER EXPOSURE Specimen Group No.	Actual Test Temp. °F	F_{ty} psi	F_{tu} psi	elong. in 2 in. %	Strain Rate in/in/min	CORRECTED PROPERTIES (2) F_{ty} psi	F_{tu} psi	STRENGTH RATIOS R_σ Yield	Ult.	R_ϵ Yield	Ult.
B-13		300°F 100 hr 29.5 ksi	350°F 24 hr 21.0 ksi	400°F 3.5 hr 19.0 ksi															
	B416	0	0	0		15.25	0	125	399	29,100	29,700	25.0	0.0094	29,000	29,700	0.430	0.381		
	B417	0	0	0		15.25	0	125	399	29,800	29,900	23.0	0.0096	29,700	29,900	0.440	0.382		
	B410	0	0	0		15.30	0	131	400	28,600	29,100	11.5	0.0099	28,600	29,100	0.425	0.374		
	B411	0	0	0		15.30	0	131	400	28,800	29,100	14.5	0.0097	28,800	29,100	0.428	0.374		
	B415	0	0	0		15.30	0	131	400	28,600	29,200	16.5	0.0094	28,600	29,200	0.425	0.375		
	B412	0.25	0.15	0.15		15.27	0.55	131	400	27,500	27,600	10.5	0.0107	27,500	27,600			0.958	0.948
	B413	0.25	0.10	0.20		15.26	0.55	131	400	26,700	27,300	14.5	0.0098	26,700	27,300			0.930	0.938
	B414	0.25	0.10	0.30		15.30	0.65	131	400	26,800	27,100	15.0	0.0105	26,800	27,100			0.934	0.931
	B513	0.20	0.15	0.20		15.25	0.55	125	395	28,200	28,200	20.0	0.0099	27,900	28,000			0.949	0.940
	B516	0.25	0.10	0.30		15.24	0.65	125	398	27,500	27,500	19.0	0.0094	27,400	27,400			0.932	0.919
	B517	0.25	0.10	0.20		15.25	0.55	125	400	28,000	28,000	15.5	0.0079	28,000	28,000			0.952	0.940
5-14		300°F 100 hr 29.5 ksi	350°F 24 hr 21.0 ksi	400°F 3.5 hr 19.0 ksi	350°F 24 hr 20.0 ksi														
	B530	0	0	0	0	15.43	0	139	400	25,200	25,200	12.0	0.007[illegible]	25,200	25,200	0.376	0.330		
	B534	0	0	0	0	15.43	0	139	400	26,200	26,900	14.5	0.0089	26,200	26,900	0.391	0.352		
	B531	0.30	0.20	0.45	1.40	15.43	2.35	139	404	26,100	27,200	9.5	0.0085	26,300	27,400			1.023	1.050
	B532	0.25	0.25	0.40	0.90	15.43	1.80	139	402	24,200	24,200	10.0	0.0072	24,300	24,300			0.946	0.931
	B533	0.25	0.20	0.85	0.90	15.41	2.20	139	397	24,800	24,900	9.0	0.0076	24,600	24,800			0.957	0.950

TABLE XV

ROOM TEMP. COMPRESSIVE STRENGTH AFTER SEQUENTIAL EXPOSURES

		NOMINAL EXPOSURE CONDITIONS AND RESULTING STRAIN *							PROPERTIES AFTER EXPOSURE				CORRECTED PROPERTIES (2)	[illegible]	
Sequence Code	Specimen No.	Step 1	Step 2	Step 3	Step 4	Total θ_{17} Exposure $x10^{-3}$ (1)	Total Strain %	Specimen Group No.	Rockwell Hardness R_F	Rockwell Hardness R_B	Actual Test Temp. °F	F_{cy} psi	F_{cy} psi	R_T	R_C
A-1		350°F 3.5 hr 31.5 ksi	315°F 20 hr 33.5 ksi	275°F 100 hr 34.5 ksi											
	C522T	0%	0%	0%		14.58	0	176	115.5	76.5	75	64,700	64,700	0.871	
	C522M	0	0	0		14.58	0	176	116.0	76.5	75	66,500	66,500	[illegible]	
	C521T	0.23	0.26	0.35		14.58	0.84	176	115.0	73.5	75	60,500	60,500		[illegible]
	C521M	0.26	0.37	0.45		14.57	1.08	176	115.0	73.0	75	58,600	58,600		0.891
	C521B	0.27	0.31	0.42		14.58	1.00	176	115.0	72.5	75	59,300	59,300		0.892
A-2		350°F 3.5 hr 27.5 ksi	315°F 20 hr 28.0 ksi	275°F 100 hr 28.5 ksi											
	C523T	0	0	0		14.58	0	183	116.0	77.0	81	65,600	65,700	0.881	
	C523M	0	0	0		14.58	0	183	116.0	78.0	81	66,200	66,300	0.932	
	C524T	0.12	0.05	0.05		14.57	0.22	183	115.5	75.0	81	63,700	63,800		.967
	C524M	0.15	0.02	0.03		14.56	0.20	183	115.5	75.5	81	65,000	65,100		[illegible]
	C524B	0.10	0.03	0.10		14.55	0.23	183	115.5	75.5	81	65,000	65,100		0.996
B-13		300°F 100 hr 29.5 ksi	350°F 24 hr 21.5 ksi	400°F 3.5 hr 19.5 ksi											
	C512T	0	0	0		15.33	0	175	111.5	62.0	75	43,800	43,800	0.590	
	C512M	0	0	0		15.33	0	175	111.5	61.5	75	42,700	42,700	0.575	
	C511T	0.26	0.13	0.19		15.34	0.58	175	109.5	56.5	75	40,500	40,500		[illegible]
	C511M	0.26	0.13	0.24		15.31	0.63	175	110.0	57.0	75	40,100	40,100		0.527
	C511B	0.24	0.17	0.22		15.30	0.63	175	110.0	56.0	75	39,900	39,900		0.523
B-14		300°F 100 hr 29.5 ksi	351°F 24 hr 21.5 ksi	400°F 3.5 hr 19.5 ksi	350°F 24 hr 20.0 ksi										
	C432T	0	0	0	0	15.42	0	182	111.0	59.5	75	42,300	42,300	0.569	
	C432M	0	0	0	0	15.42	0	182	111.0	59.0	75	42,500	42,500	0.572	
	C431T	0.25	0.11	0.24	0.17	15.40	0.77	182	109.5	55.0	75	39,300	39,300		0.527
	C431M	0.20	0.18	0.22	0.17	15.40	0.77	182	109.5	54.0	75	38,700	38,700		0.513
	C431B	0.19	0.15	0.24	0.16	15.40	0.74	182	109.0	55.5	75	39,800	39,800		0.534

* Specimen inelastic strains during each step. These are listed below nominal exposure conditions. (Values derived by subtraction of cumulative strain readings obtained at the end of each step, are only approximate.)

(1) Actual exposure temperatures (± 4°F from nominal) were used to compute θ_{17}.

(2) Corrected to nominal test temperatures.

(2) Corrected to nominal test temperatures.

TABLE XV (Continued)

ROOM TEMP. COMPRESSIVE STRENGTH AFTER SEQUENTIAL EXPOSURES

Sequence Code	Specimen No.	Nominal Exposure Conditions and Resulting Strain * Step 1	Step 2	Step 3	Step 4	Total Θ_{17} Exposure $\times 10^{-3}$ (1)	Total Strain %	Specimen Group No.	Properties After Exposure: Rockwell Hardness R_H	R_B	Actual Test Temp. °F	F_{cy} psi	Corrected Properties (2): F_{cy} psi	Strength Ratios: R_σ	R_ϵ
B-2		300°F 100 hr 21.0 ksi	350°F 24 hr 19.5 ksi	400°F 3.5 hr 14.5 ksi	350°F 24 hr 14.5 ksi										
	C432T	0%	0%	0%	0%	15.43	0	186	111.0	59.0	82	42,700	42,700	[illegible]	
	C433S	0	0	0	0	15.43	0	186	111.0	59.5	82	42,[illegible]00	42,[illegible]00	[illegible]	
	C435T	0.05	0.09	0.03	0.03	15.44	0.20	186	110.0	55.5	82	41,300	41,300		0.965
	C435M	0.04	0.13	0.03	0.02	15.43	0.22	186	110.0	[illegible]	82	41,600	41,600		0.972
	C435B	0.04	0.10	0.03	0.04	15.44	0.21	186	110.0	56.0	82	40,900	40,900		0.956
B-14a		300°F 100 hr 29.5 ksi	350°F 24 hr 21.5 ksi	400°F 3.5 hr 19.5 ksi	350°F 24 hr 0 ksi										
	C433T	0	0	0	0	15.40	0	187	110.5	59.0	82	42,600	42,600	0.575	
	C433M	0	0	0	0	15.40	0	187	110.0	59.0	82	42,400	42,400	0.572	
	C434T	0.22	0.07	0.27	0	15.40	0.56	187	110.0	55.0	82	39,800	39,800		0.937
	C434M	0.24	0.07	0.23	0	15.39	0.54	187	110.0	55.0	82	39,400	39,400		0.927
	C434B	0.22	0.15	0.16	0	15.41	0.53	187	110.0	55.0	82	39,300	39,300		0.925
D		350°F 70 hr 0 ksi	375°F 3 hr 22.5 ksi												
	C622T	0	0			15.35	0	210	111.0	57.5	91	43,100	43,200	0.581	
	C622M	0	0			15.35	0	210	111.0	58.0	91	42,400	42,500	0.572	
	C621T	0	0.39			15.35	0.39	210	110.0	56.5	91	41,300	41,400		0.966
	C621M	0	0.39			15.34	0.39	210	110.5	56.0	91	41,300	41,400		0.966
	C621B	0	0.36			15.34	0.36	210	110.5	57.0	91	42,200	42,300		0.987

TABLE XV (Continued)
ROOM TEMP. COMPRESSIVE STRENGTH AFTER SEQUENTIAL EXPOSURES

Sequence Code	Specimen No.	Step 1	Step 2	Step 3	Step 4	Step 5	Step 6	Step 7	Step 8	Step 9	Step 10	Total θ_{17} Exposure x10^{-3}	Total Strain %	Specimen Group No.	Rockwell Hardness $R_{[illegible]}$	Rockwell Hardness R_B	Actual Test Temp. °F	F_{cy} psi	Corr. F.R.P. (2) F_{cy} psi	Strength Ratios $R_{[illegible]}$	Strength Ratios R_e
		NOMINAL EXPOSURE CONDITIONS AND RESULTING STRAIN *													PROPERTIES AFTER EXPOSURE						
A-1		340°F 10 hr [illegible] ksi	325°F 36 hr 0 ksi	375°F 3 hr 22.5 ksi	[illegible]00°F 90 hr 24.0 ksi	350°F 10 hr 22.5 ksi	225°F 36 hr 19.5 ksi	375°F 3 hr 0 ksi	300°F 100 hr 21.5 ksi	325°F 36 hr 22.0 ksi	375°F 3 hr 0 ksi										
	[illegible]	0	0	0	0	0	0	0	0	0	0	15.41	0	241			79	[illegible]	[illegible]	[illegible]	
	[illegible]	0	0	0	0	0	0	0	0	0	0	15.39	0	181	110.5	60.0	81	[illegible]	[illegible]	[illegible]	
	[illegible]	0	0	0	0	0	0	0	0	0	0	15.39	0	181	110.5	60.0	81	[illegible]	[illegible]	[illegible]	
	[illegible]	0	0	[illegible]	0	0	0	0	0	0	0	15.41	0	241			79	[illegible]	[illegible]	[illegible]	
	[illegible]	[illegible]	0	[illegible]	[illegible]	[illegible]	[illegible]	0	0.09	0.10**	0	15.38	0.73	181	109.5	[illegible]	81	[illegible]	[illegible]		[illegible]
	[illegible]	[illegible]	0	[illegible]	[illegible]	[illegible]	[illegible]	0	0.17	0.04**	0	15.37	0.74	181	109.5	[illegible]	81	[illegible]	[illegible]		[illegible]
	[illegible]	[illegible]	0	[illegible]	[illegible]	[illegible]	[illegible]	0	0.04	0.15**	0	15.37	0.76	181	109.5	54.5	81	[illegible]	[illegible]		[illegible]
	[illegible]	[illegible]	0	[illegible]	[illegible]	[illegible]	0.10	0	0.06	0.18	0	15.41	0.91	241			79	[illegible]	[illegible]		[illegible]
	[illegible]	0.13	0	0.07	[illegible]	0.31	-0.07*	0	0.02	0.14	0	15.40	0.75	241			79	[illegible],000	[illegible]		[illegible]
	[illegible]	[illegible]	0	0.05	0.12	[illegible]	0.04	0	0.16	0.02	0	15.39	0.73	241			79	[illegible],100	[illegible]		[illegible]

** 12 hrs. at 22.4 ksi, 24 hrs at 0 ksi

TABLE XVI

300°F COMPRESSIVE STRENGTH AFTER SEQUENTIAL EXPOSURES

Sequence Code	Specimen No.	Nominal Exposure Conditions and Resulting Strain *				Total θ_{17} Exposure $x10^{-3}$ (1)	Total Strain %	Specimen Group No.	Properties After Exposure		Corrected Properties (2)	Strength Ratios	
		Step 1	Step 2	Step 3	Step 4				Actual Test Temp. °F	F_{cy} psi	F_{cy} psi	R_T	R_ϵ
A-1		350°F 3.5 hr 31.5 ksi	315°F 20 hr 33.5 ksi	275°F 100 hr 34.5 ksi									
	C527T	0%	0%	0%		14.56	0	188	300	54,100	54,100	.723	
	C527B	0	0	0		14.56	0	188	300	53,700	53,700	.723	
	C526T	0.22	0.22	0.32		14.57	0.76	188	300	47,900	47,900		.883
	C526M	0.21	0.23	0.28		14.55	0.72	188	300	47,300	47,300		.878
	C526B	0.21	0.25	0.28		14.56	0.74	188	300	48,600	48,600		.902
A-2		350°F 3.5 hr 27.5 ksi	315°F 20 hr 28.0 ksi	275°F 100 hr 28.5 ksi									
	C523B	0	0	0		14.56	0	189	303	52,700	53,000	.713	
	C522B	0	0	0		14.56	0	189	302	53,700	53,900	.725	
	C525T	0.11	0.11	0.03		14.55	0.25	189	303	52,200	52,400		.980
	C525M	0.11	0.11	0.05		14.56	0.27	189	302	52,200	52,400		.980
	C525B	0.17	0.04	0.07		14.56	0.28	189	303	50,800	51,000		.954
B-13		300°F 100 hr 29.5 ksi	350°F 24 hr 21.5 ksi	400°F 3.5 hr 19.5 ksi									
	C513T (3)	0	0	0		15.32	0	190	300	38,000	38,000	.511	
	C513M (3)	0	0	0		15.32	0	190	300	37,500	37,500	.505	
	C514M	0.28	0.13	0.29		15.30	0.70	190	301	33,700	33,800		.895
	C514B	0.30	0.14	0.35		15.31	0.79	190	303	33,900	34,100		.903
B-14		300°F 100 hr 29.5 ksi	350°F 24 hr 21.5 ksi	400°F 3.5 hr 19.5 ksi	350°F 24 hr 20.0 ksi								
	C437T	0	0	0	0	15.43	0	191	302	36,200	36,300	.489	
	C437M	0	0	0	0	15.43	0	191	299	36,700	36,600	.493	
	C436T	0.21	0.15	0.24	0.24	15.42	0.84	191	300	33,400	33,400		.916
	C436M	0.20	0.15	0.23	0.26	15.40	0.84	191	301	32,600	32,700		.897
	C436B	0.21	0.14	0.23	0.24	15.41	0.82	191	303	32,300	32,400		.889

* Specimen inelastic strains during each step. These are listed below nominal exposure conditions. (Values derived by subtraction of cumulative strain readings obtained at the end of each step, are only approximate.)

(1) Actual exposure temperatures (± 4°F from nominal) were used to compute θ_{17}.

(2) Corrected to nominal test temperatures.

(3) Strain rates for specimens C513T and C513M were 0.013 and 0.015 in/in/min respectively. (rest were 0.007 - 0.011)

TABLE XVII
TENSION CONTROL TESTS FOR COMPRESSION PROGRAM

Initial Exposure Conditions: Temp. °F	Time hr	θ_{17} T(17+log t) X10^{-3}	Actual Exposure Conditions: Specimen No.	Temp. °F	Time hr	Specimen Group No.	Properties After Exposure: Rockwell Hardness R_H	R_B	Actual Test Temp. °F	F_{ty} psi	F_{tu} psi	elong in 2in. %	Corrected Properties: F_{ty} psi	F_{tu} psi	Strength Ratios: R_T Yield	Ultimate
300	1	12.92	C337T *	298	1	173	116.5	80.0	75	68,300	77,300	9.0	68,300	77,300	0.999	1.016
300	1	12.92	C337B *	298	1	173	117.0	80.5	75	68,900	78,200	9.5	68,900	78,200	1.007	1.028
250	100	13.49	C235T *	251	100	172	117.0	81.5	75	67,500	75,900	11.0	67,500	75,900	0.987	0.997
250	100	13.49	C235B *	251	100	172	117.0	82.5	75	67,100	76,000	11.0	67,100	76,000	0.981	0.999
300	100	14.44	C322T *	301	100	179	116.0	76.5	75	61,500	71,100	9.5	61,800	71,400	0.904	0.938
300	100	14.44	C322B *	301	100	179	115.0	77.5	75	60,700	71,100	9.5	61,000	71,400	0.892	0.938
350	10	14.58	C415T *	352	10	177	106.0	78.0	75	58,500	70,500	10.5	59,200	71,000	0.865	0.933
350	10	14.58	C415B *	352	10	177	106.0	77.0	75	57,200	68,600	10.5	57,900	69,100	0.846	0.908
350	10	14.58	C726T	352	10	225	- - -	- -	301	49,700	50,300	17.0	50,000	50,600	0.731	0.665
350	10	14.58	C726B	352	10	225	- - -	- -	300	49,000	49,800	16.0	49,300	50,100	0.721	0.658
377	3	14.63	C620T *	377	3	216	- - -	- -	90	54,700	66,800	9.5	55,300	67,300	0.810	0.880
377	3	14.63	C520T *	378	3	216	- - -	- -	90	57,200	69,000	11.0	58,000	69,700	0.850	0.920
377	3	14.63	C620B *	378	3	216	- - -	- -	90	57,000	68,700	11.0	57,700	69,300	0.840	0.910
350	80	15.31	C312T *	350	80	185	112.0	62.5	82	40,400	55,700	9.5	40,400	56,100	0.591	0.737
350	80	15.31	C312B *	350	80	185	112.0	61.5	82	40,100	54,900	10.5	40,100	55,300	0.586	0.727
400	10	15.48	C425T *	400	10	178	111.0	59.0	75	39,100	54,400	9.5	39,100	54,400	0.572	0.715
400	10	15.48	C425B *	400	10	178	111.5	60.0	75	39,400	54,900	9.5	39,400	54,900	0.574	0.721
500	10	17.28	C615T *	501	10	174	98.5	12.0	75	19,700	39,300	11.5	19,700	39,300	0.288	0.516
500	10	17.28	C615B *	501	10	174	98.5	14.0	75	19,300	38,600	12.5	19,300	39,600	0.282	0.520
500	10	17.28	C723T	502	10	226	- - -	- -	300	18,500	25,500	35.0	18,500	25,500	0.270	0.335
500	10	17.28	C723B	502	10	226	- - -	- -	301	18,200	25,200	35.0	18,200	25,300	0.266	0.334
500	10	17.28	C724T	502	10	226	- - -	- -	400	16,200(1)	17,100	47.0	16,200	17,100	0.237	0.225
500	10	17.28	C724B	502	10	226	- - -	- -	400	16,400(1)	17,200	48.0	16,400	17,200	0.240	0.226

* Specimens pulled with flat grips.

(1) Strain rate - 0.012 in/in/min

TABLE XVIII
ORIGINAL STRENGTH AND STRENGTH AFTER REFERENCE EXPOSURE

Test Temp. °F	Sheet	ORIGINAL STRENGTH F_f (1) Tensile Yield psi	Tensile Ultimate psi	Comp. Yield psi	STRENGTH AFTER REFERENCE EXPOSURE (2) F_1 (1) Tensile Yield psi	Tensile Ultimate psi	Comp. Yield psi	CHANGE IN STRENGTH $F_f - F_1$ Tensile Yield psi	Tensile Ultimate psi	Comp. Yield psi
R.T.	A	68,300	78,300	-	25,800	43,600	-	42,500	34,700	-
	B	67,000	76,400	-	26,000	44,400	-	41,000	32,000	-
	C	68,400	76,100	74,300	-	-	28,300	-	-	46,000
200	A	65,000	69,900	-	24,500	38,000	-	40,500	31,900	-
	B	-	-	-	-	-	-	-	-	-
	C	-	-	70,700	-	-	27,400	-	-	43,300
300	A	57,000	58,300	-	24,500	28,400	-	32,500	29,900	-
	B	54,400	56,200	-	24,400	28,500	-	30,000	27,700	-
	C	56,400	58,100	63,100	-	-	26,300	-	-	36,800
400	A	42,000	43,600	-	20,300	20,400	-	21,700	23,200	-
	B	42,700	44,200	-	20,700	21,200	-	22,000	23,0[illegible]	-
	C	43,100	44,400	47,500	-	-	21,600	-	-	25,900

(1) Average Strength Values. Refer to Tables III through XI

(2) Reference Exposure = 450°F - 10 hr.

TABLE XIX
STRENGTH DETERIORATION FACTOR FOR SINGLE EXPOSURE - UNSTRESSED AND STRESSED

EXPOSURE CONDITIONS			STRENGTH AT TEMPERATURE AFTER EXPOSURE F_{ef} (1)				STRENGTH DETERIORATION FACTOR FOR UNSTRESSED EXPOSURE $D = \frac{F_{ef} - F_1}{F_f - F_1}$ (2)			STRENGTH DETERIORATION FACTOR FOR STRESSED EXPOSURE 0.2% INELASTIC STRAIN $D = \frac{F_{ef} - F_1}{F_f - F_1}$ (2) (3)			STRENGTH DETERIORATION FACTOR FOR STRESSED EXPOSURE 1.0% INELASTIC STRAIN $D = \frac{F_{ef} - F_1}{F_f - F_1}$ (2) (3)		
Temp. °F	Time hr	θ_{17} T(17+log t) x10⁻³	Test Temp. °F	Tensile Yield psi	Tensile Ultimate psi	Comp. Yield psi	Tensile Yield	Tensile Ultimate	Comp. Yield	Tensile Yield	Tensile Ultimate	Comp. Yield	Tensile Yield	Tensile Ultimate	Comp. Yield
300	1	12.92	R.T.	67,100	77,200	73,700	0.972	0.968	0.986	1.003	1.013	0.986	1.035	0.990	0.92[illegible]
300	1	12.92	300	55,900	58,300	61,100	0.966	1.000	0.945	1.001	1.039	0.945	1.035	1.029	0.8[illegible]
250	100	13.49	R.T.	68,300	77,200	75,300	1.000	0.968	1.021	1.000	0.968	1.005	0.984	0.924	0.923
250	100	13.49	300	56,000	57,400	60,600	0.969	0.969	0.932	0.969	0.969	0.915	0.952	0.931	0.833
250	100	13.49	400	41,900	43,200	47,400	0.995	0.982	0.996	0.995	0.982	0.978	0.976	0.942	0.981
300	100	14.44	R.T.	60,100	71,900	67,100	0.807	0.815	0.843	0.765	0.753	0.814	0.708	0.671	0.683
300	100	14.44	200	58,300	62,600	- - -	0.834	0.771	- - -	0.791	0.712	- - -	0.734	0.634	- - -
300	100	14.44	300	51,900	52,700	56,400	0.843	0.812	0.818	0.795	0.760	0.787	0.731	0.689	0.649
300	100	14.44	400	39,100	39,700	- - -	0.866	0.831	- - -	0.812	0.781	- - -	0.740	0.712	- - -
350	10	14.58	R.T.	57,800	68,900	61,300	0.752	0.729	0.717	0.712	0.669	0.691	0.658	0.590	0.571
350	10	14.58	200	- - -	- - -	59,300	- - -	- - -	0.736	- - -	- - -	0.709	- - -	- - -	0.582
350	10	14.58	300	48,200	48,700	54,400	0.729	0.678	0.763	0.685	0.630	0.734	0.626	0.565	0.601
350	10	14.58	400	- - -	- - -	41,500	- - -	- - -	0.768	- - -	- - -	0.735	- - -	- - -	0.592
350	24	14.89	R.T.	49,400	62,600	- - -	0.555	0.548	- - -	0.509	0.510	- - -	0.451	0.403	- - -
350	24	14.89	300	44,200	45,200	- - -	0.606	0.561	- - -	0.546	0.532	- - -	0.492	0.441	- - -
350	80	15.31	R.T.	40,800	56,500	44,500	0.352	0.371	0.352	0.324	0.339	0.333	0.266	0.258	0.255
350	80	15.31	300	35,600	36,900	37,700	0.341	0.284	0.310	0.309	0.260	0.289	0.243	0.198	0.207
400	10	15.48	R.T.	39,300	55,300	40,300	0.318	0.337	0.260	0.290	0.305	0.243	0.234	0.241	0.182
400	10	15.48	200	37,800	47,000	40,800	0.328	0.282	0.309	0.300	0.253	0.290	0.244	0.194	0.225
400	10	15.48	300	34,100	35,600	36,500	0.295	0.240	0.277	0.264	0.217	0.257	0.201	0.169	0.254
400	10	15.48	400	27,800	28,100	29,800	0.345	0.331	0.316	0.307	0.308	0.293	0.230	0.259	0.213
450	10	16.38	R.T.	25,800	43,600	28,300	0	0	0	-0.012	-0.013	-0.006	-0.031	-0.026	-0.043
450	10	16.38	200	24,500	38,000	27,400	0	0	0	-0.012	-0.012	-0.006	-0.030	-0.025	-0.044
450	10	16.38	300	24,500	28,400	26,300	0	0	0	-0.015	-0.009	-0.007	-0.037	-0.020	-0.049
450	10	16.38	400	20,300	20,400	21,600	0	0	0	-0.018	-0.009	-0.008	-0.046	-0.017	-0.058
500	10	17.28	R.T.	19,200	38,500	20,800	-0.155	-0.144	-0.163	-0.160	-0.155	-0.161	-0.178	-0.166	-0.186
500	10	17.28	200	- - -	- - -	22,700	- - -	- - -	-0.108	- - -	- - -	-0.113	- - -	- - -	-0.135
500	10	17.28	300	18,700	25,400	20,000	-0.178	-0.100	-0.171	-0.200	-0.109	-0.177	-0.207	-0.117	-0.198
500	10	17.28	400	- - -	- - -	17,500	- - -	- - -	-0.158	- - -	- - -	-0.166	- - -	- - -	-0.192
600	8	18.98	R.T.	15,500	37,000	- - -	-0.242	-0.190	- - -	- - -	- - -	- - -	- - -	- - -	- - -
600	8	18.98	200	15,300	36,600	- - -	-0.227	-0.043	- - -	- - -	- - -	- - -	- - -	- - -	- - -
600	8	18.98	300	14,900	27,400	- - -	-0.295	-0.093	- - -	- - -	- - -	- - -	- - -	- - -	- - -
600	8	18.98	400	13,700	16,800	- - -	-0.304	-0.155	- - -	- - -	- - -	- - -	- - -	- - -	- - -

(1) Average strength values - refer to Tables IV through XI. Tensile data are from Sheet A tests only.
(2) Refer to columns 5 through 7 for F_{ef} and to Table XVIII for F_1 and $F_f - F_1$.
(3) F_{ef} for stressed exposure is F_{ef} for unstressed exposure multiplied by appropriate R_t from Figure 16.

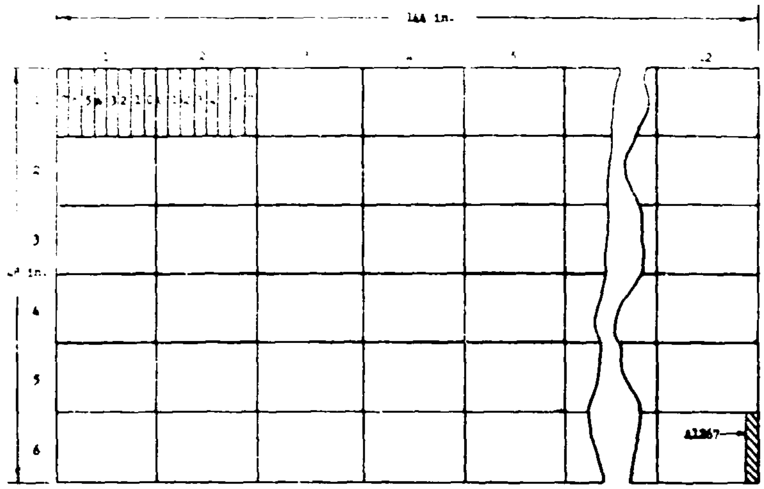
TABLE XX
STRENGTH DETERIORATION FACTOR FOR MULTIPLE EXPOSURES - UNSTRESSED

Sequence	Total θ_{17} $X10^{-3}$ (1)	Test Temp. °F	STRENGTH AT TEMPERATURE AFTER EXPOSURE F_{ef} (2) Tensile Yield psi	Tensile Ultimate psi	Comp. Yield psi	STRENGTH DETERIORATION FACTOR FOR UNSTRESSED EXPOSURE $D = \frac{F_{ef} - F_1}{F_f - F_1}$ (3) Tensile Yield	Tensile Ultimate	Comp. Yield
A-1	14.60	R. T.	61,000	71,700	65,600	0.828	0.809	0.810
	14.60	300	50,500	50,600	53,900	0.800	0.742	0.750
	14.60	400	33,600	38,600	-	0.843	0.784	-
A-2	14.60	R. T.	59,900	71,500	66,000	0.802	0.804	0.819
	14.60	300	50,600	52,400	53,500	0.803	0.802	0.739
	14.60	400	38,100	39,700	-	0.820	0.831	-
A'-1	14.60	R. T.	57,500	69,100	-	0.745	0.734	-
A'-2	14.60	R. T.	59,900	70,300	-	0.802	0.769	-
B-12	15.00	R. T.	46,800	60,400	-	0.495	0.484	-
	15.00	300	42,400	43,200	-	0.550	0.494	-
	15.00	400	33,500	34,200	-	0.608	0.594	-
B-13	15.30	R. T.	41,400	56,800	43,300	0.376	0.388	0.326
	15.30	300	34,700	36,600	37,800	0.343	0.292	0.313
	15.30	400	28,900	29,400	-	-	-	-
B'-13	15.30	R. T.	43,900	58,200	-	0.437	0.431	-
	15.30	300	37,100	38,200	-	0.423	0.350	-

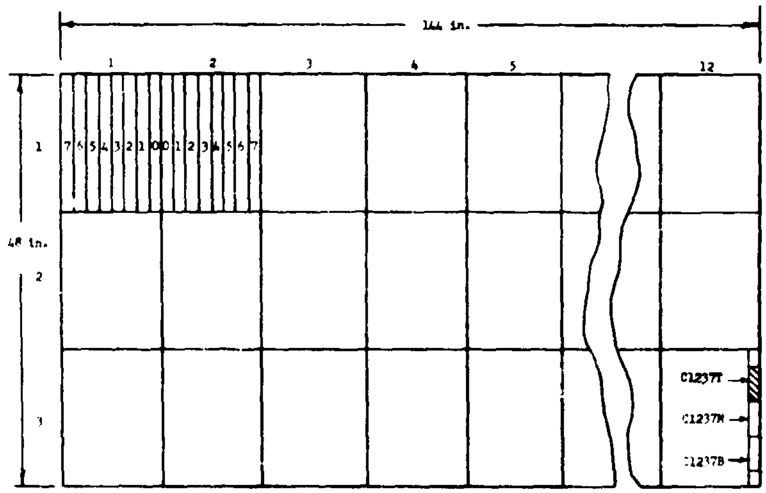
(1) Average values of θ, carried to 3 significant figures only.
(2) Averages of individual strength values from Tables XII through XVI. Tensile specimens for A sequences and B-12 sequence were taken from sheet A. Rest of tensile specimens (above) were from Sheet B.
(3) Refer to Table XVIII for values of F_1 and $F_f - F_1$.

TABLE XX (Continued)
STRENGTH DETERIORATION FACTOR FOR MULTIPLE EXPOSURES - UNSTRESSED

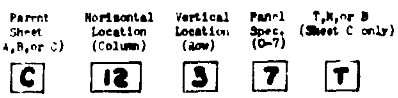
Sequence	Total θ_{17} X10-3 (1)	Test Temp. °F	STRENGTH AT TEMPERATURE AFTER EXPOSURE F_{ef} (2) Tensile Yield psi	Tensile Ultimate psi	Comp. Yield psi	STRENGTH DETERIORATION FACTOR FOR UNSTRESSED EXPOSURE $D = \frac{F_{ef} - F_1}{F_f - F_1}$ (3) Tensile Yield	Tensile Ultimate	Comp. Yield
B-14	15.40	R. T.	37,900	53,400	42,400	0.290	0.281	0.306
	15.40	300	34,700	36,000	36,500	0.343	0.270	0.277
	15.40	400	25,700	26,100	-	0.245	0.213	-
B-24	15.40	R. T.	37,900	53,000	42,800	0.290	0.269	0.315
	15.40	300	34,100	35,500	-	0.323	0.253	-
B-13a	15.30	R. T.	41,100	56,200	-	0.368	0.369	-
B-14a	15.40	R. T.	39,600	54,300	42,500	0.332	0.309	0.308
	15.40	300	33,900	35,100	-	0.317	0.238	-
D	15.30	R. T.	44,200	58,800	42,900	0.444	0.450	0.317
	15.30	300	37,500	38,800	-	0.437	0.372	-
E-1	15.40	R. T.	38,900	54,300	42,400	0.315	0.309	0.306
	15.40	300	34,300	36,100	-	0.330	0.274	-
E-2	15.40	R. T.	39,900	54,600	-	0.339	0.319	-
E-3	15.40	R. T.	38,700	53,900	-	0.310	0.297	-



(a) Tension Specimen Identification, Sheets A and B

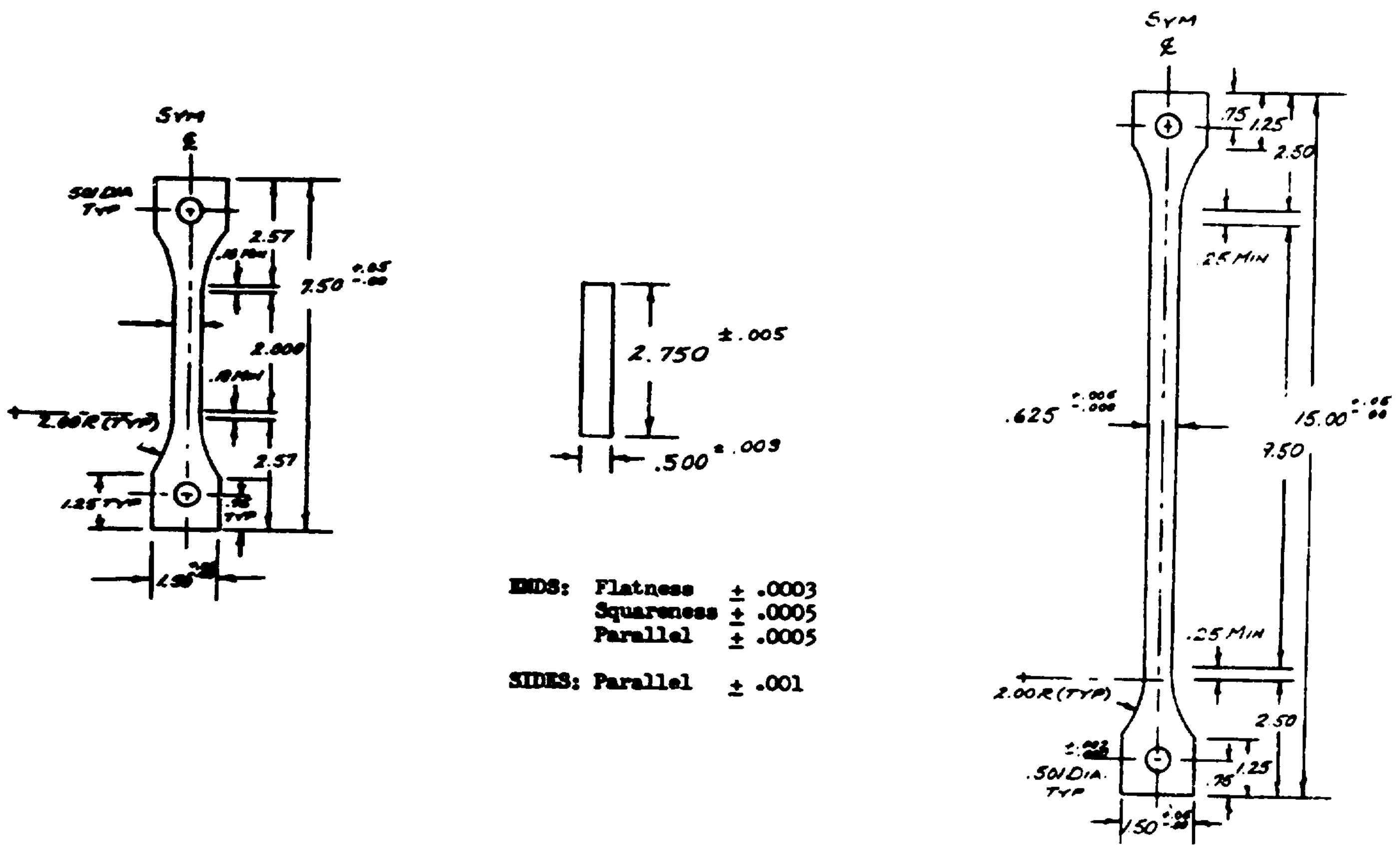


(b) Compression Specimen Identification, Sheet C



(c) Specimen Numbering Code

FIGURE 1 IDENTIFICATION OF TENSION AND COMPRESSION SPECIMENS



TENSILE SPECIMEN

COMPRESSION SPECIMEN

CREEP EXPOSURE SPECIMEN

FIGURE 2 TEST SPECIMEN DETAILS

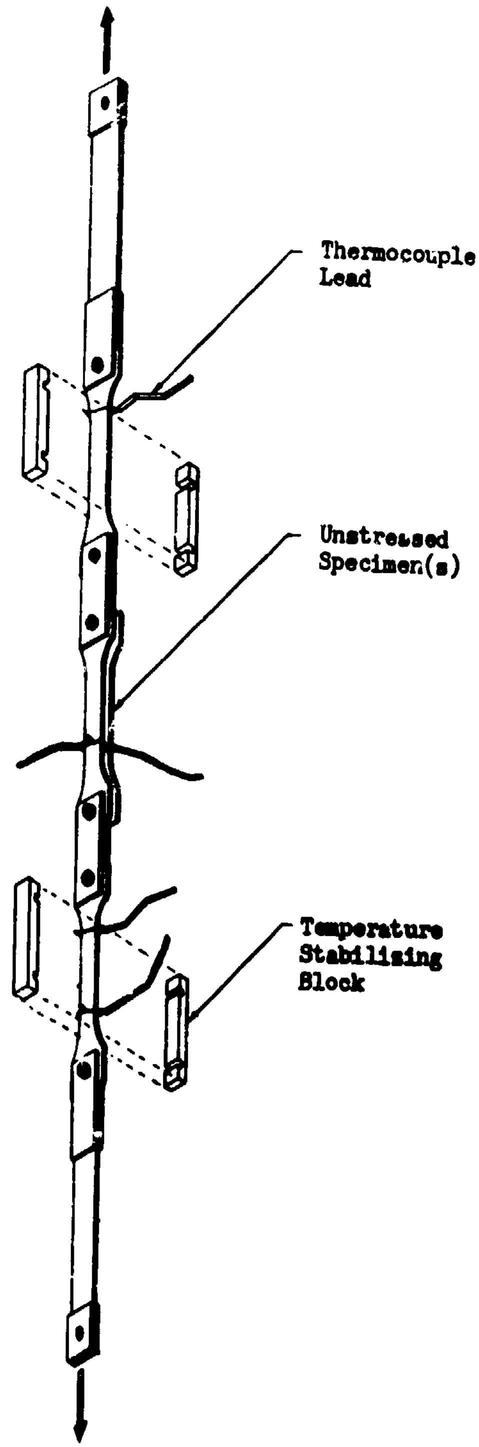
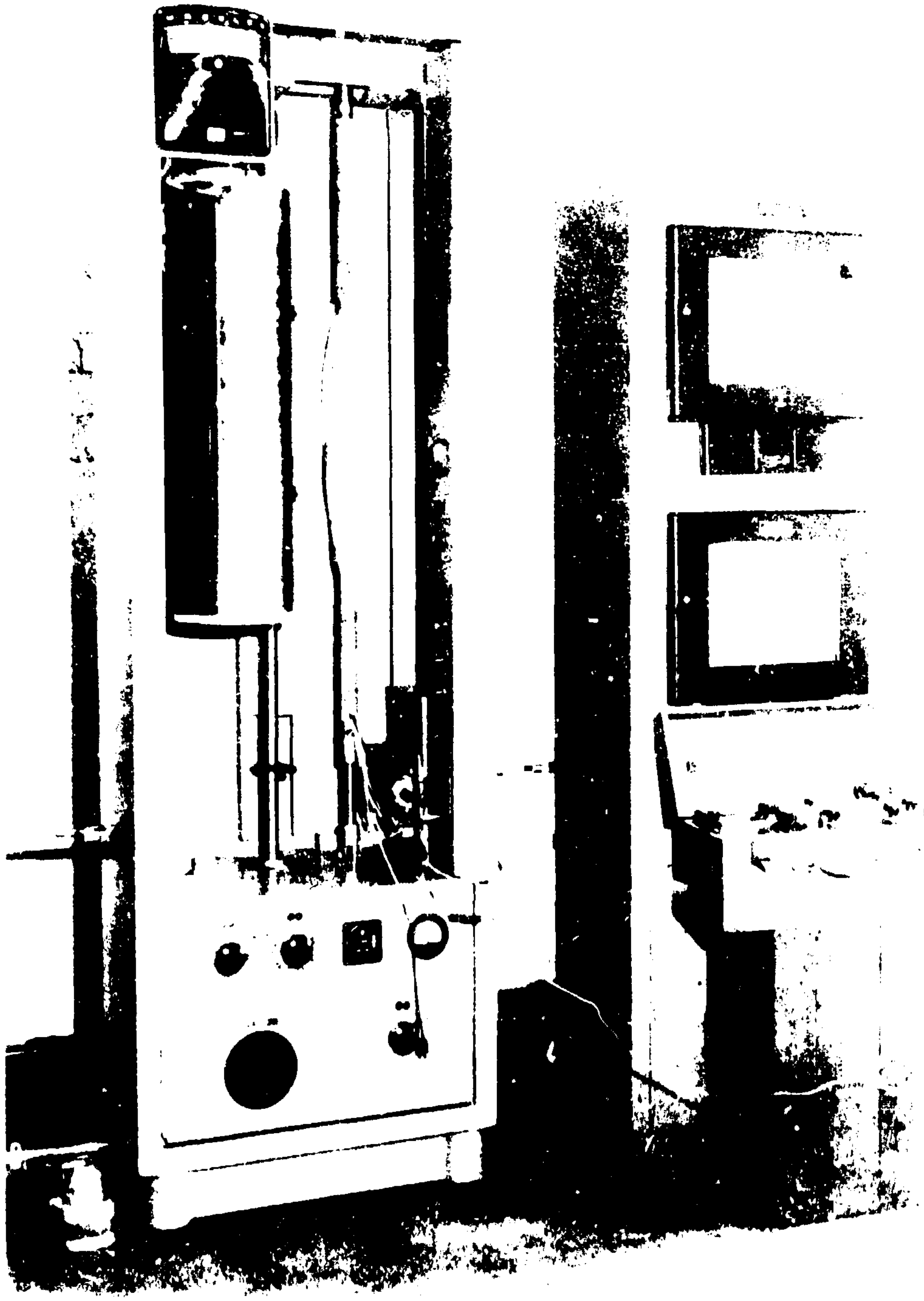
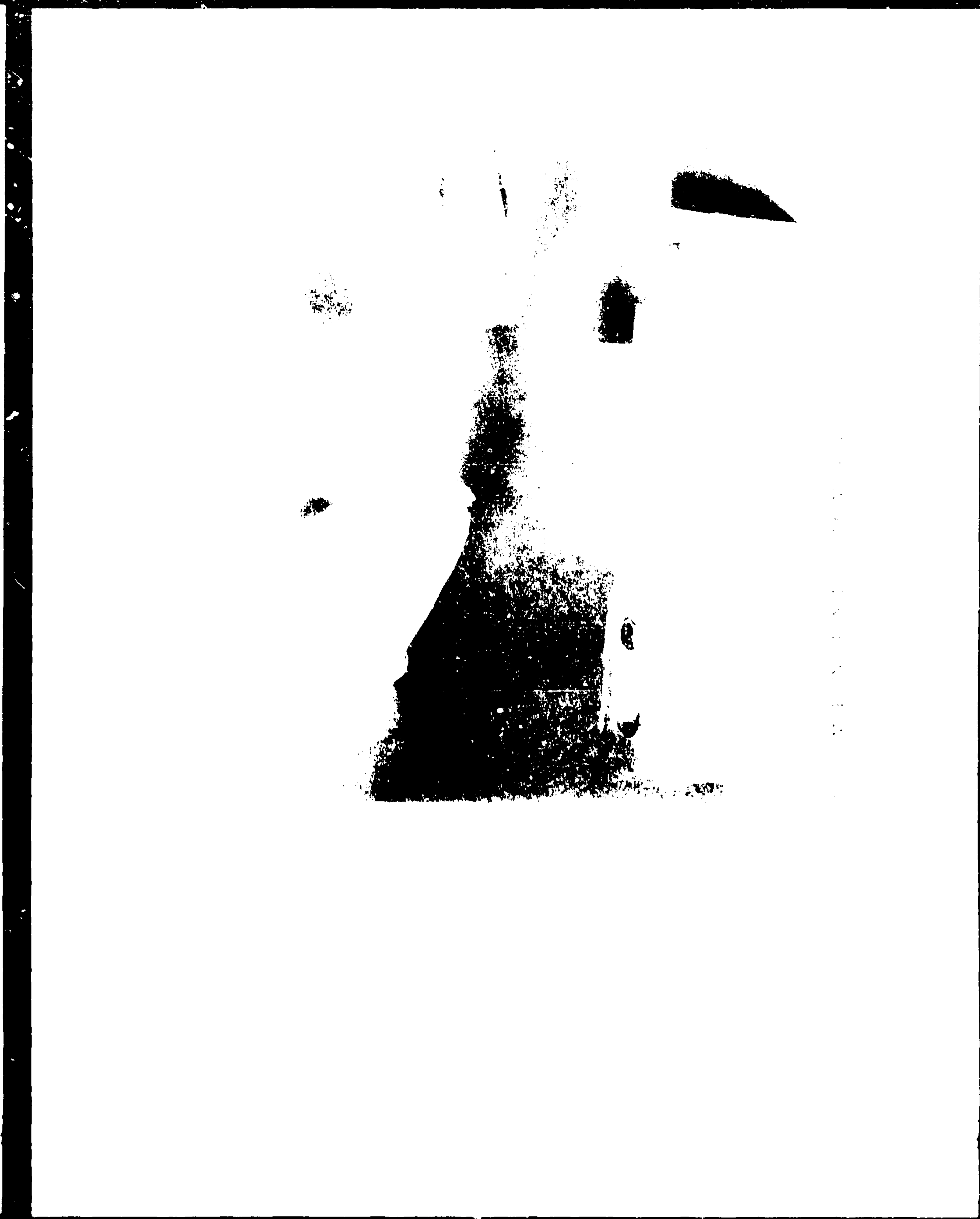
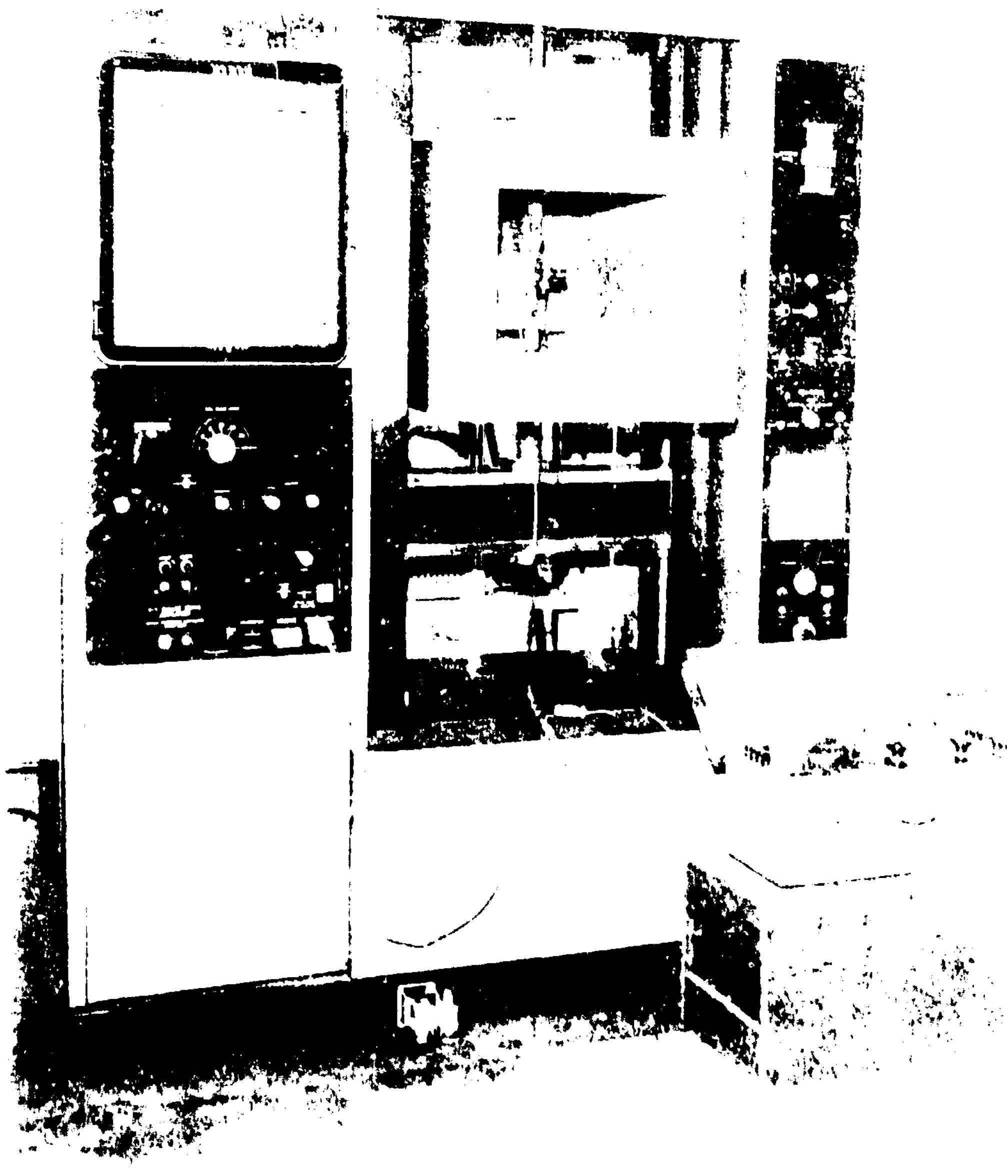
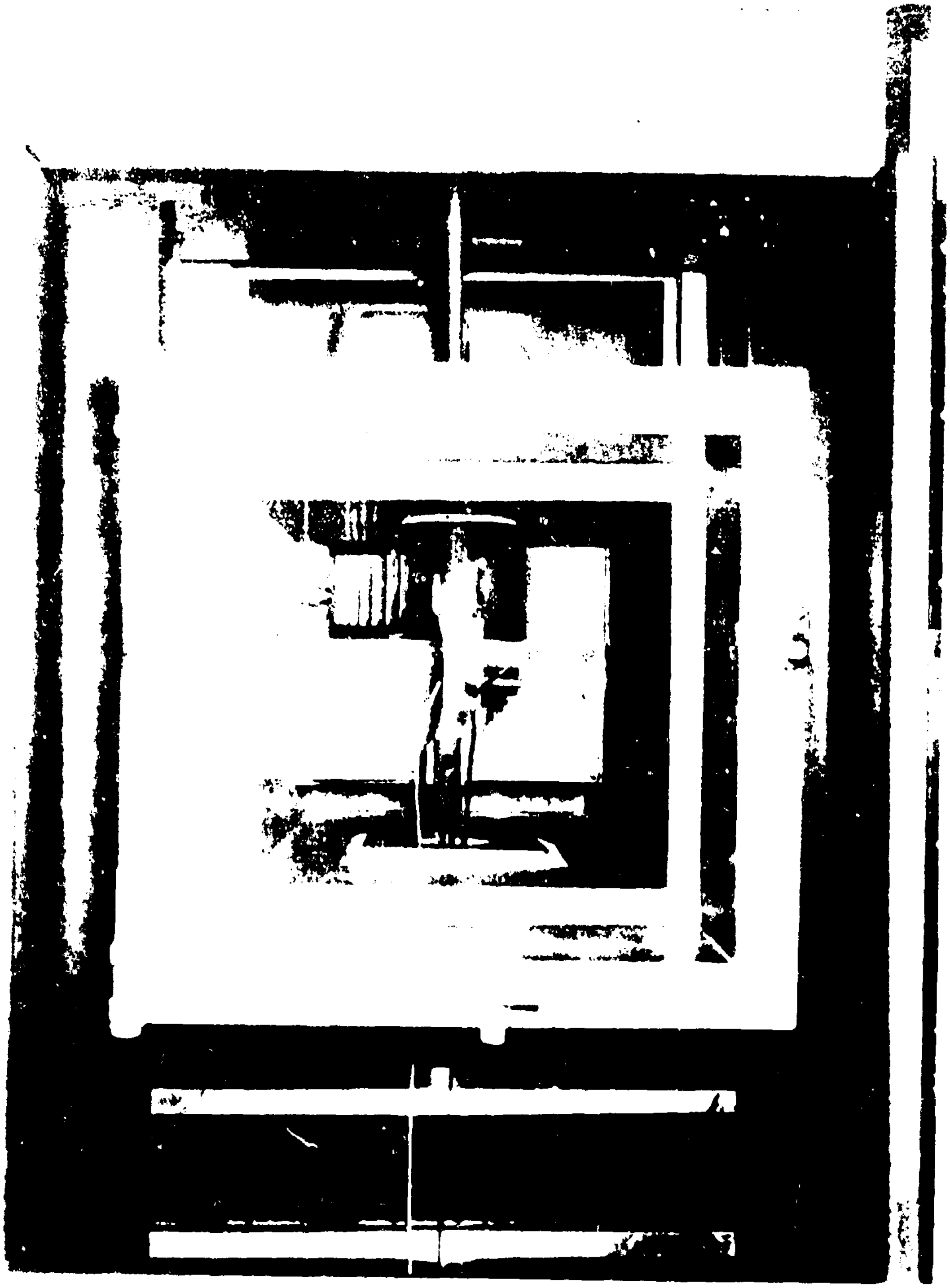


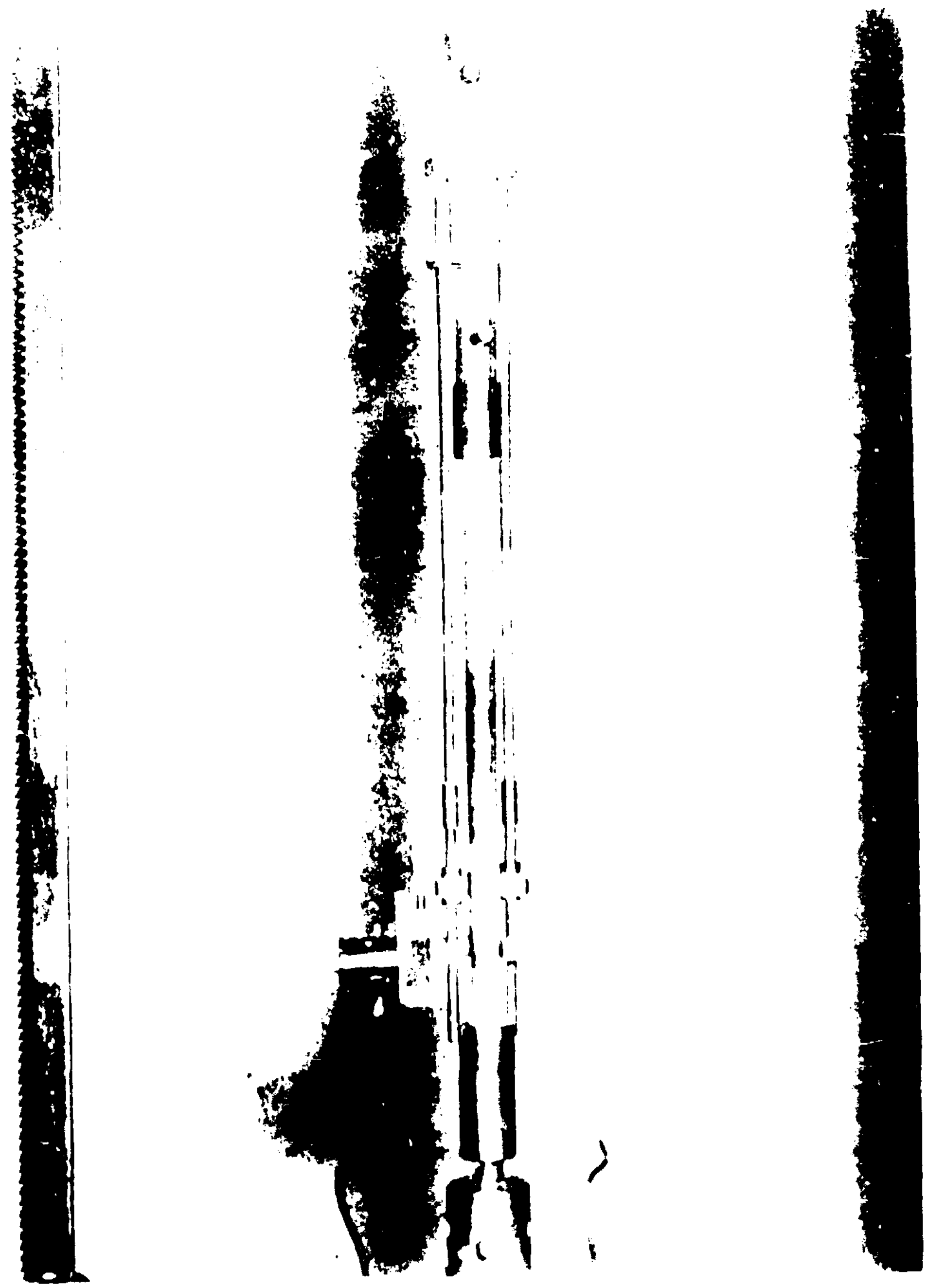
FIGURE 3 TENSION SPECIMEN EXPOSURE ASSEMBLY

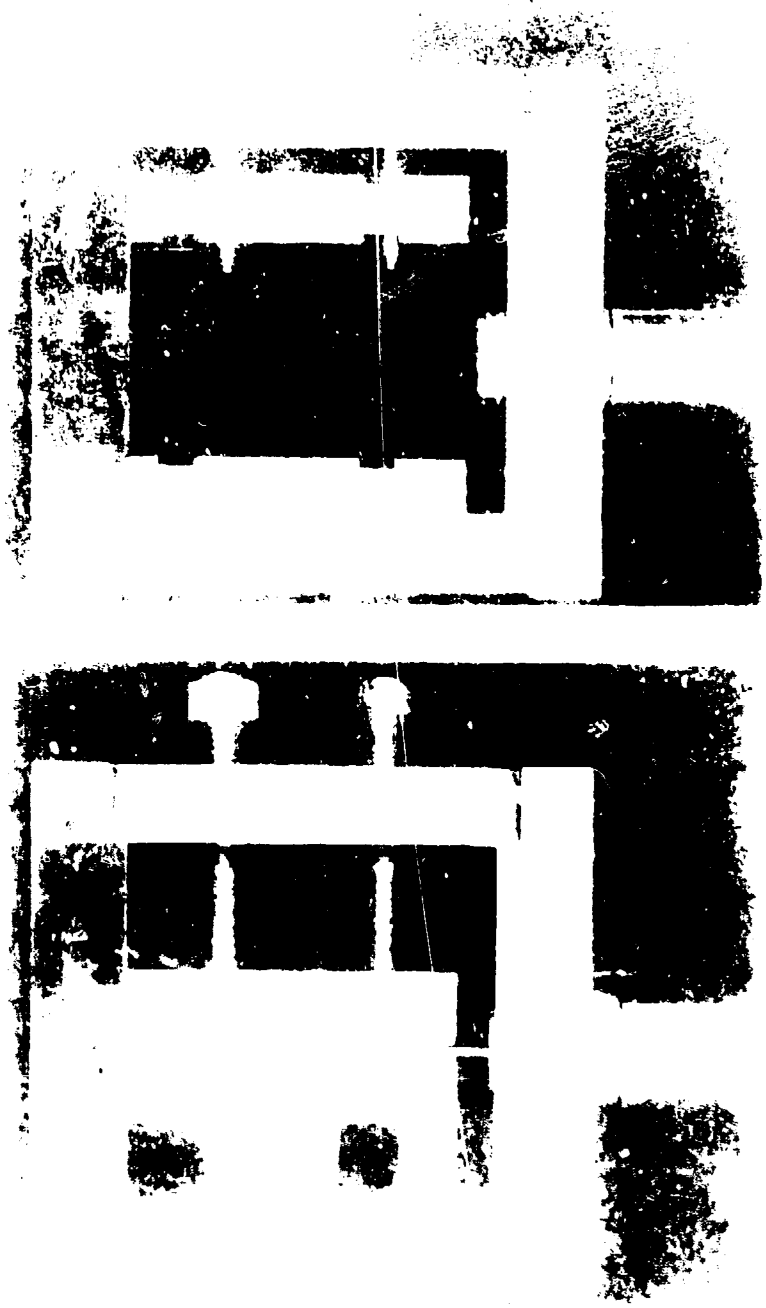








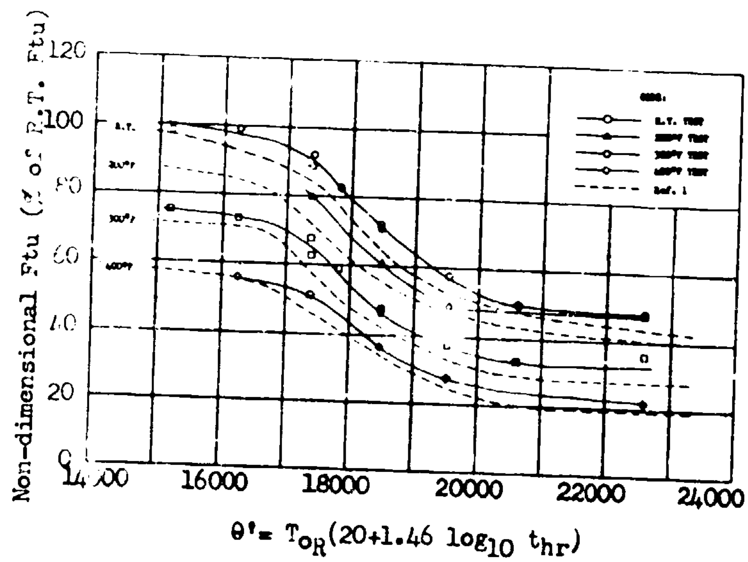




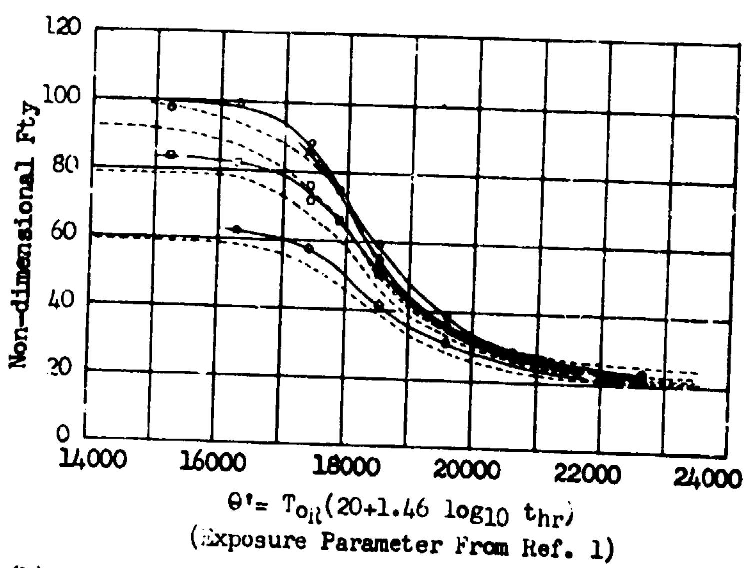
Yld	Ult	Yld	Ult	Yld	Ult	Yld	Ult	Yld	Ult	Yld	Ult
68.7 67.9	78.5 78.0	68.0 67.5	78.3 78.0			68.8 69.2	79.1 79.9			69.1 69.0	78.5 78.4
				69.2 69.5	77.8 78.5			67.7 67.1	77.4 77.7		
		68.2 68.2	78.8 78.8			68.3 69.4	78.9 78.9			69.4 69.4	78.5 78.8
68.0 67.5	78.1 77.5			68.1 65.3	77.0 77.5			65.8 67.5	76.7 78.1		
		67.6 67.7	77.5 77.6			67.5 67.9	77.3 78.1			68.7	78.1
67.2 78.5	Yld 67.5 Ult 77.5			70.0 70.1	80.5 79.3			68.0 68.4	78.9 79.3		Yld 70.8 Ult 77.7

		F_{ty}	F_{tu}
Sheet A (Above)	Maximum	70,800 psi	80,500 psi
	Minimum	65,300	76,700
	Average	68,300	78,300
Approx. universal average for 0.063 in. 7075-T6 Alclad		67,000	77,000

FIGURE 11 TENSILE STRENGTH VARIATION THROUGHOUT ONE SHEET OF TEST MATERIAL

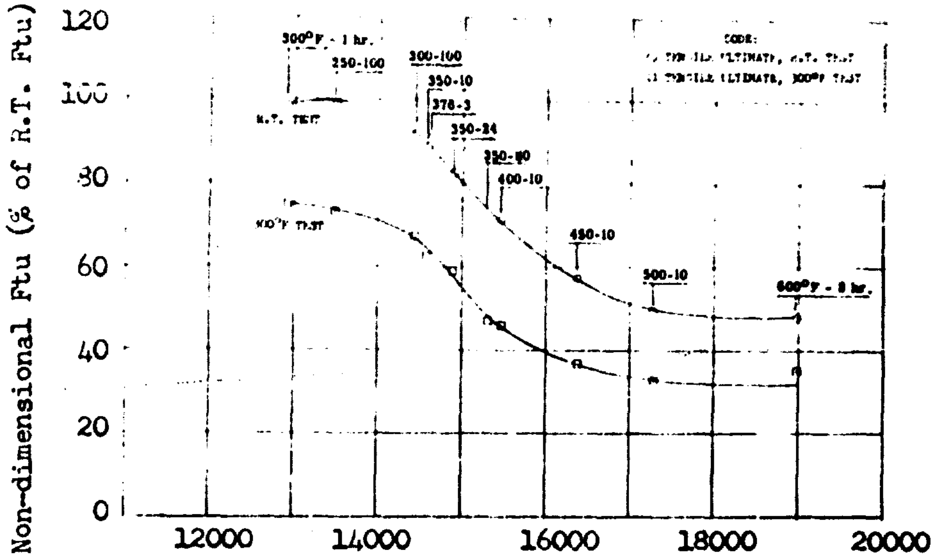


(a) **Ultimate Strength**

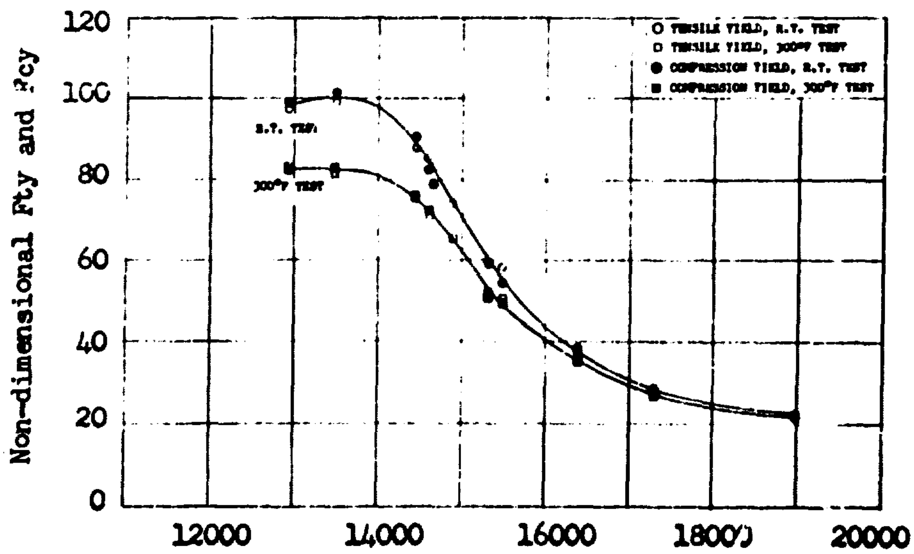


(b) **Yield Strength**

FIGURE 12 COMPARISON OF STRENGTH AFTER UNSTRESSED EXPOSURE FOR TWO LOTS OF 7075-T6



(a) Ultimate Strength $\theta_{17} = T(17 + \log t)$



(b) Yield Strength $\theta_{17} = T(17 + \log t)$

FIGURE 13 CORRELATION OF STRENGTH REDUCTION AFTER EXPOSURE WITH EXPOSURE PARAMETER θ_{17}

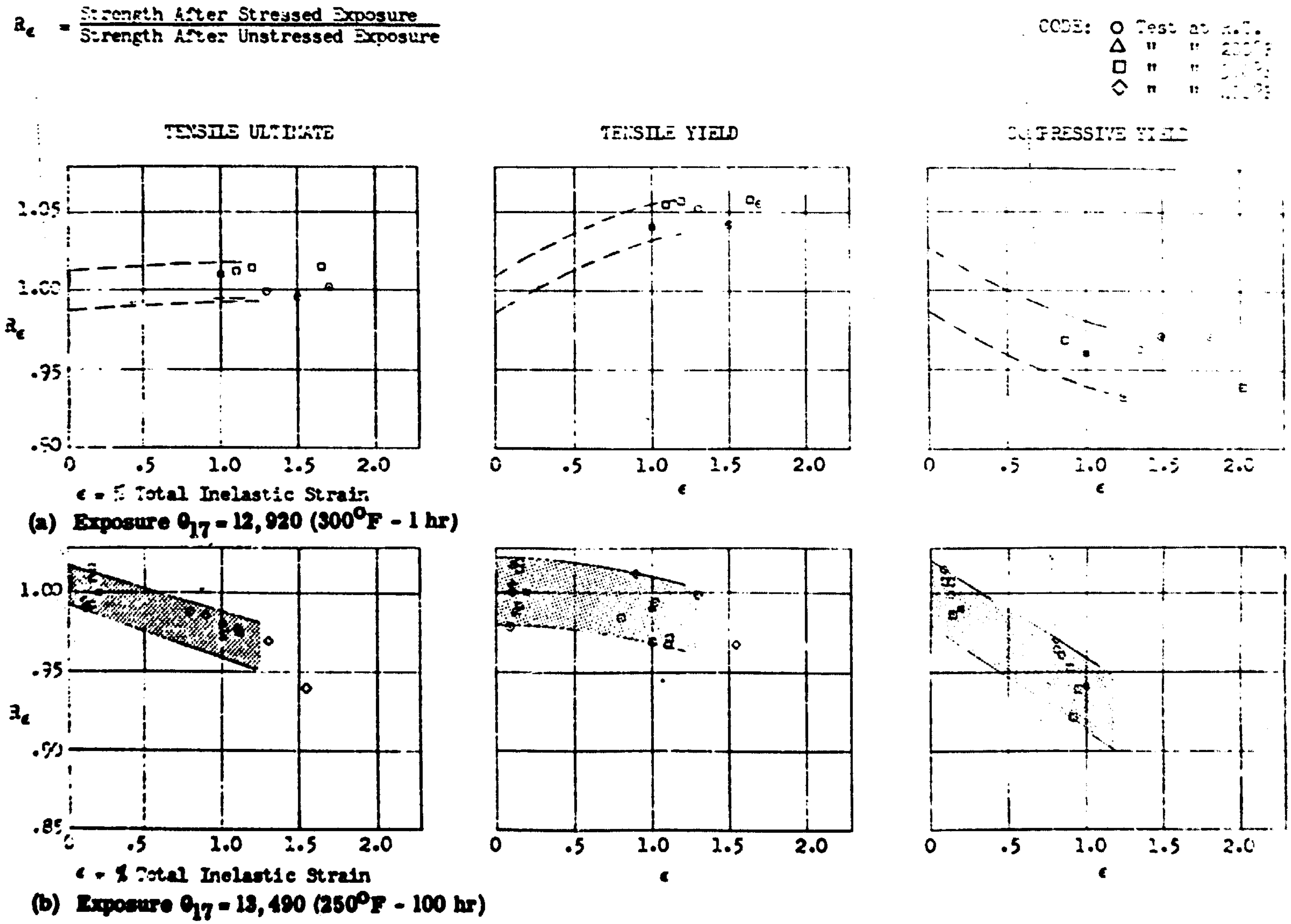
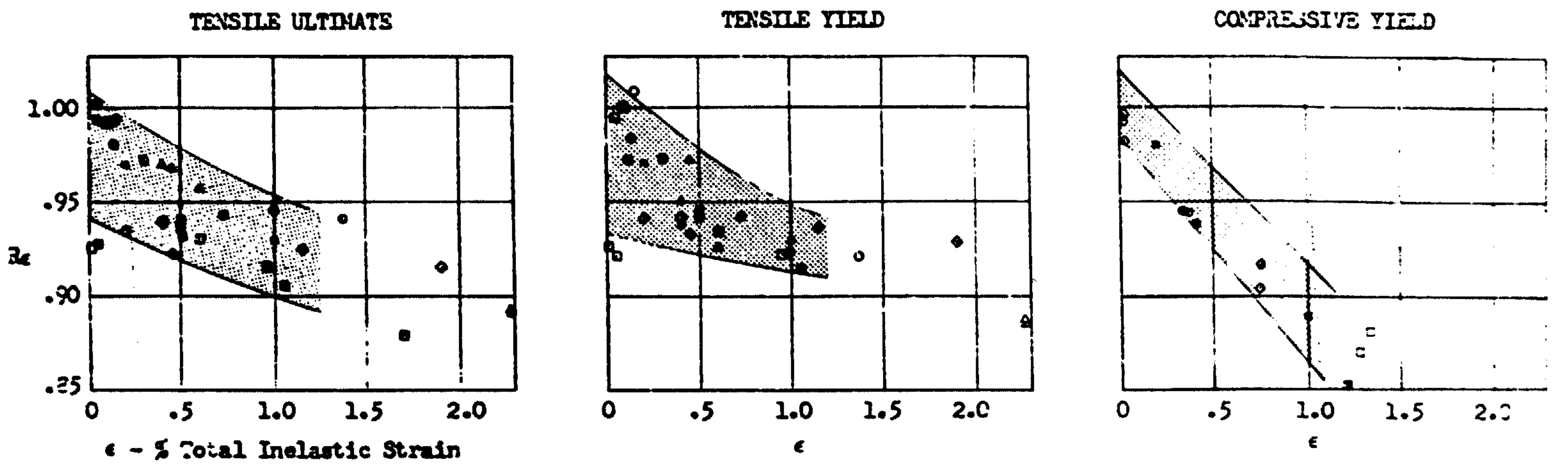
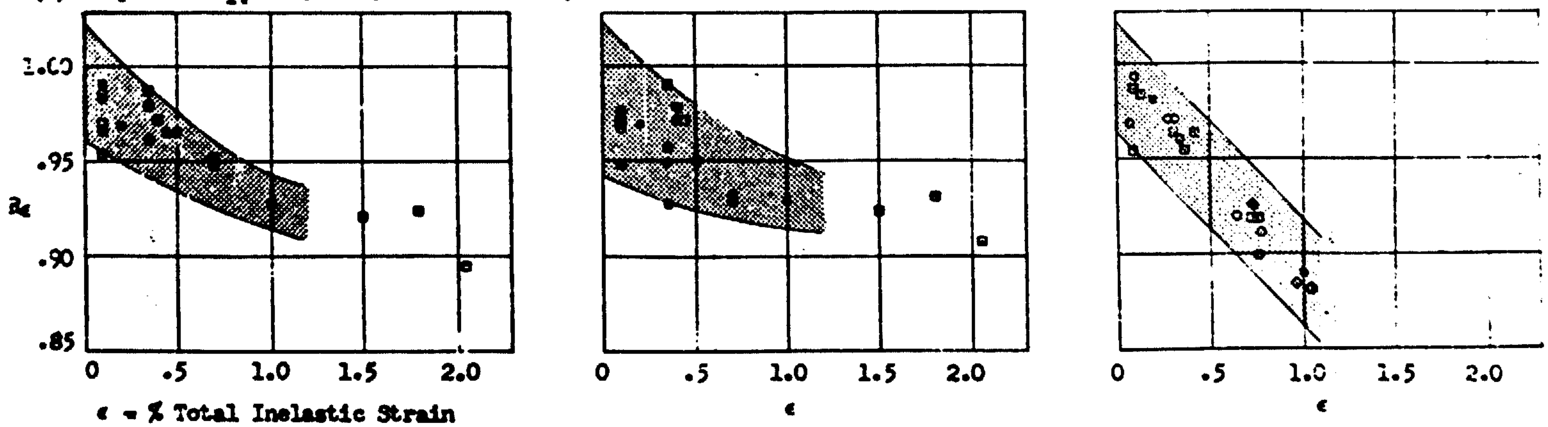


FIGURE 14 EFFECT OF EXPOSURE-ACCUMULATED TENSILE STRAIN ON SUBSEQUENT STRENGTH -- SINGLE EXPOSURE

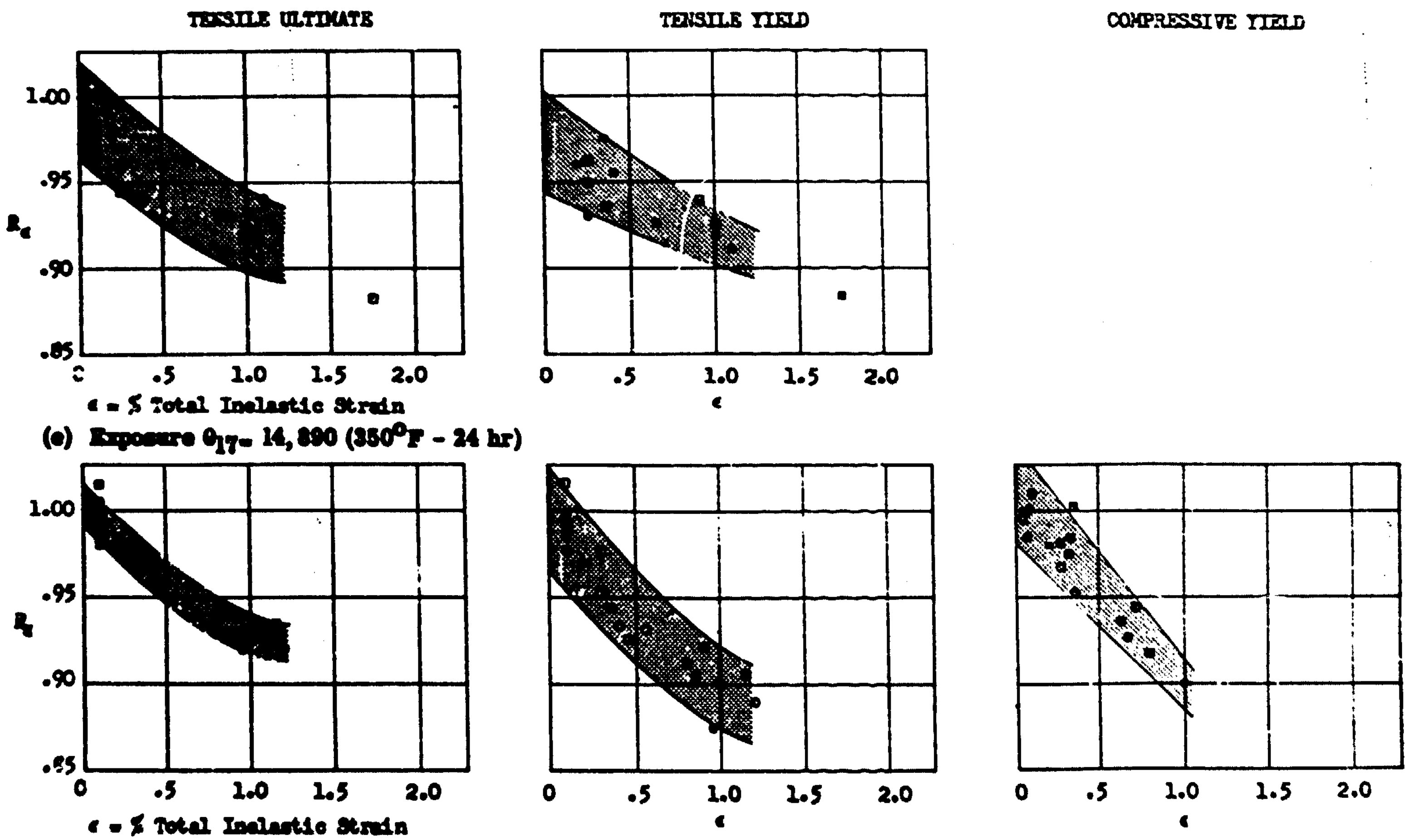


(c) Exposure θ_{17} = 14,400 (300°F - 100 hr)



(d) Exposure θ_{17} = 14,580 (350°F - 10 hr)

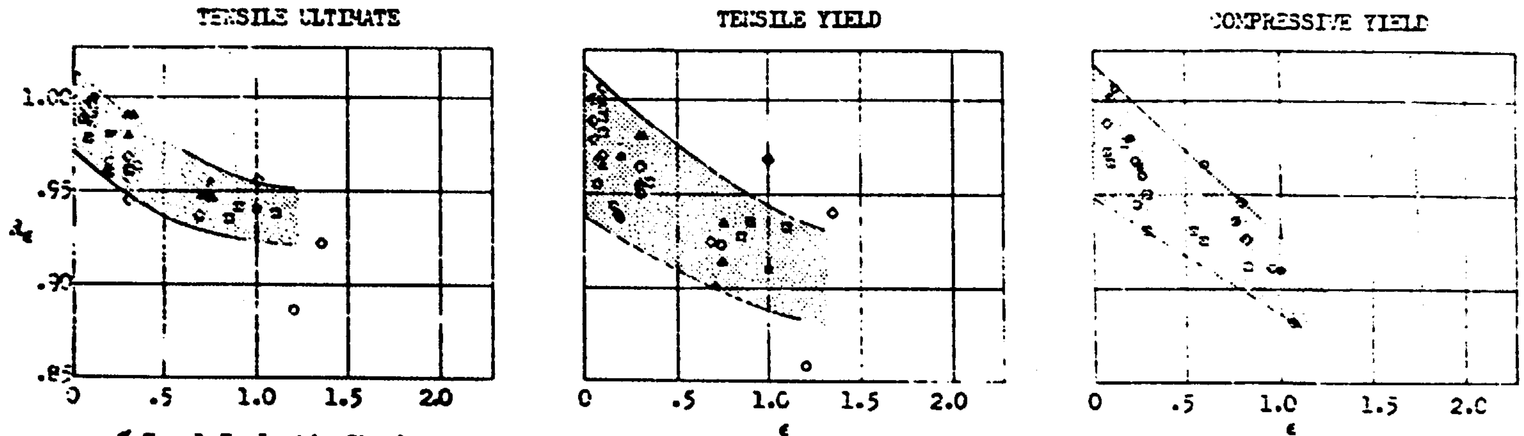
FIGURE 14 (Cont.) EFFECT OF EXPOSURE-ACCUMULATED TENSILE STRAIN ON SUBSEQUENT STRENGTH -- SINGLE EXPOSURE



(e) Exposure θ_{17} = 14,890 (350°F - 24 hr)

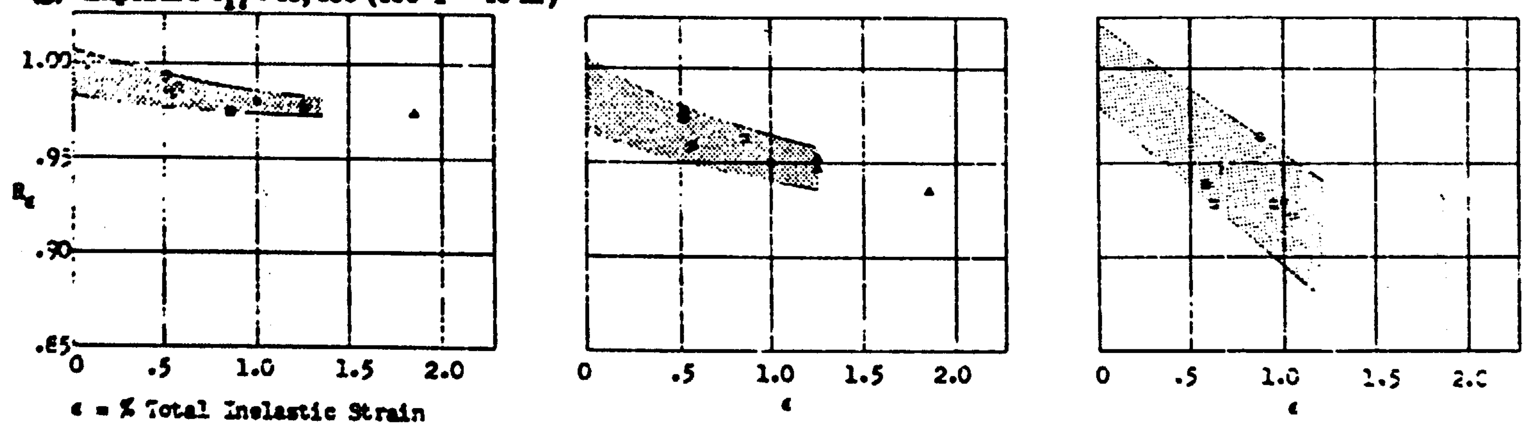
(f) Exposure θ_{17} = 15,210 (350°F - 80 hr)

FIGURE 14 (Cont.) EFFECT OF EXPOSURE-ACCUMULATED TENSILE STRAIN ON SUBSEQUENT STRENGTH -- SINGLE EXPOSURE



ε = % Total Inelastic Strain

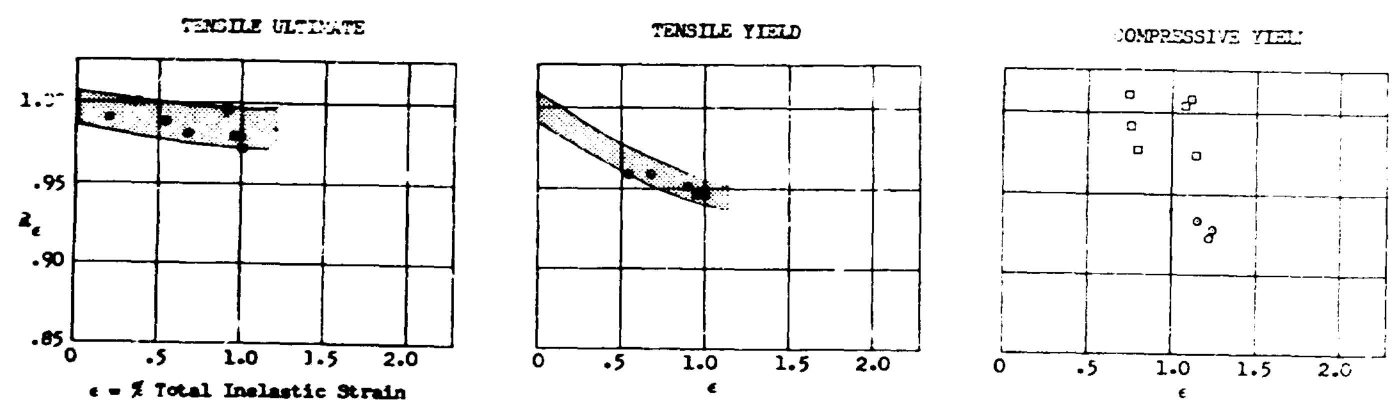
(g) Exposure θ_{17} = 15,480 (400°F - 10 hr)



ε = % Total Inelastic Strain

(h) Exposure θ_{17} = 16,380 (450°F - 10 hr)

FIGURE 14 (Cont.) EFFECT OF EXPOSURE-ACCUMULATED TENSILE STRAIN ON SUBSEQUENT STRENGTH -- SINGLE EXPOSURE



(i) Exposure θ_{17} = 17,280 (500°F - 10 hr)

FIGURE 14 (Cont.) EFFECT OF EXPOSURE-ACCUMULATED TENSILE STRAIN ON SUBSEQUENT STRENGTH -- SINGLE EXPOSURE

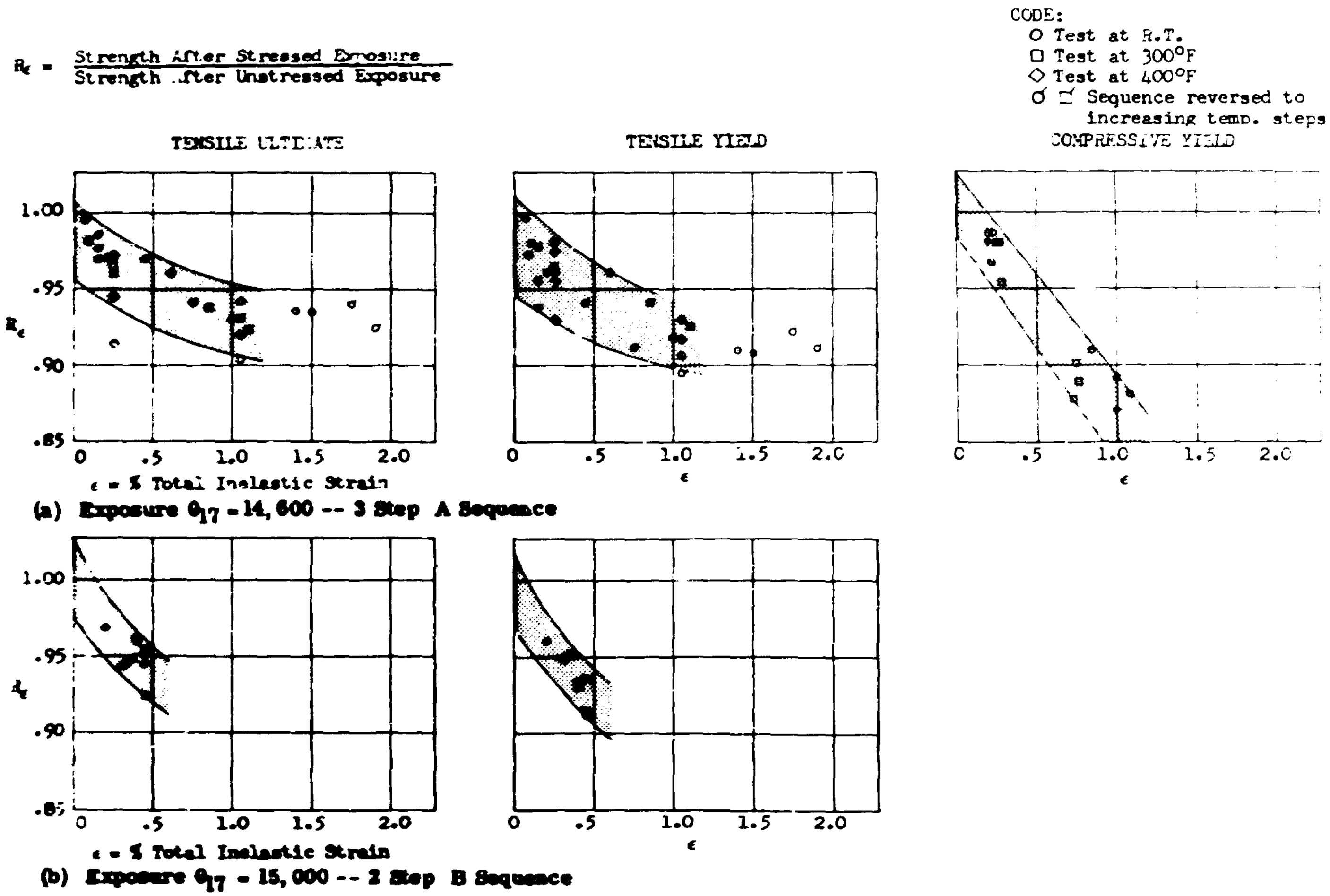
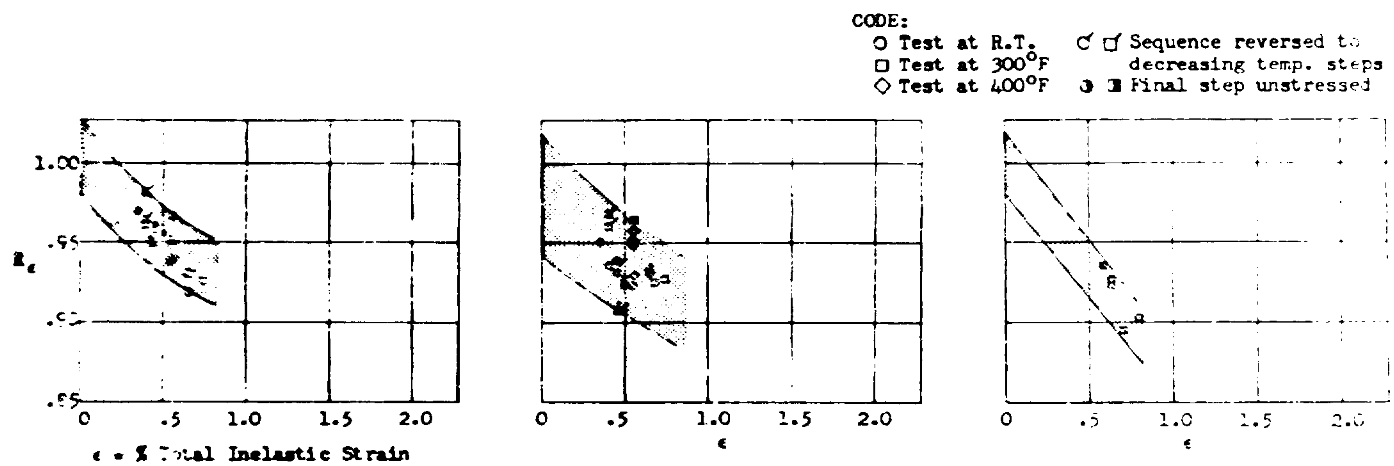
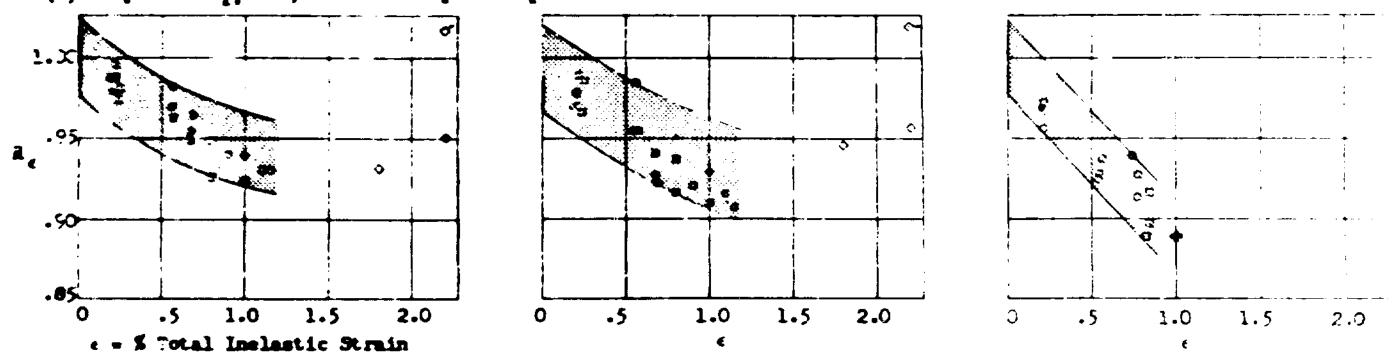


FIGURE 15 EFFECT OF EXPOSURE-ACCUMULATED TENSILE STRAIN ON SUBSEQUENT STRENGTH -- MULTIPLE EXPOSURE

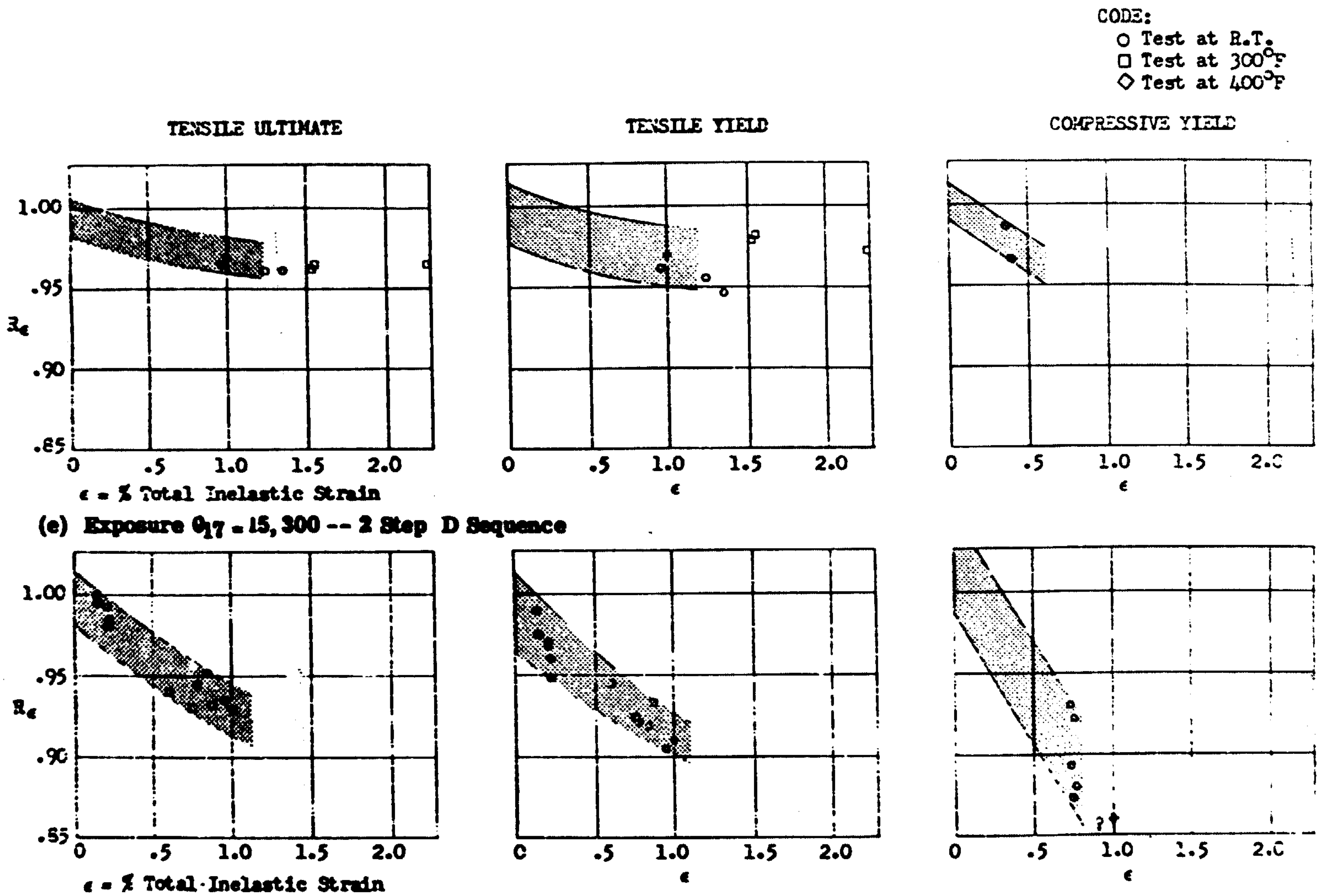


(c) Exposure θ_{17} = 15,250 -- 3 Step B Sequence



(d) Exposure θ_{17} = 15,400 -- 4 Step B Sequence

FIGURE 15 (Cont.) EFFECT OF EXPOSURE-ACCUMULATED TENSILE STRAIN ON SUBSEQUENT STRENGTH -- MULTIPLE EXPOSURE



(e) Exposure θ_{17} = 15,300 -- 2 Step D Sequence

(f) Exposure θ_{17} = 15,400 -- 10 Step E Sequence

FIGURE 15 (Cont.) EFFECT OF EXPOSURE-ACCUMULATED TENSILE STRAIN ON SUBSEQUENT STRENGTH -- MULTIPLE EXPOSURE

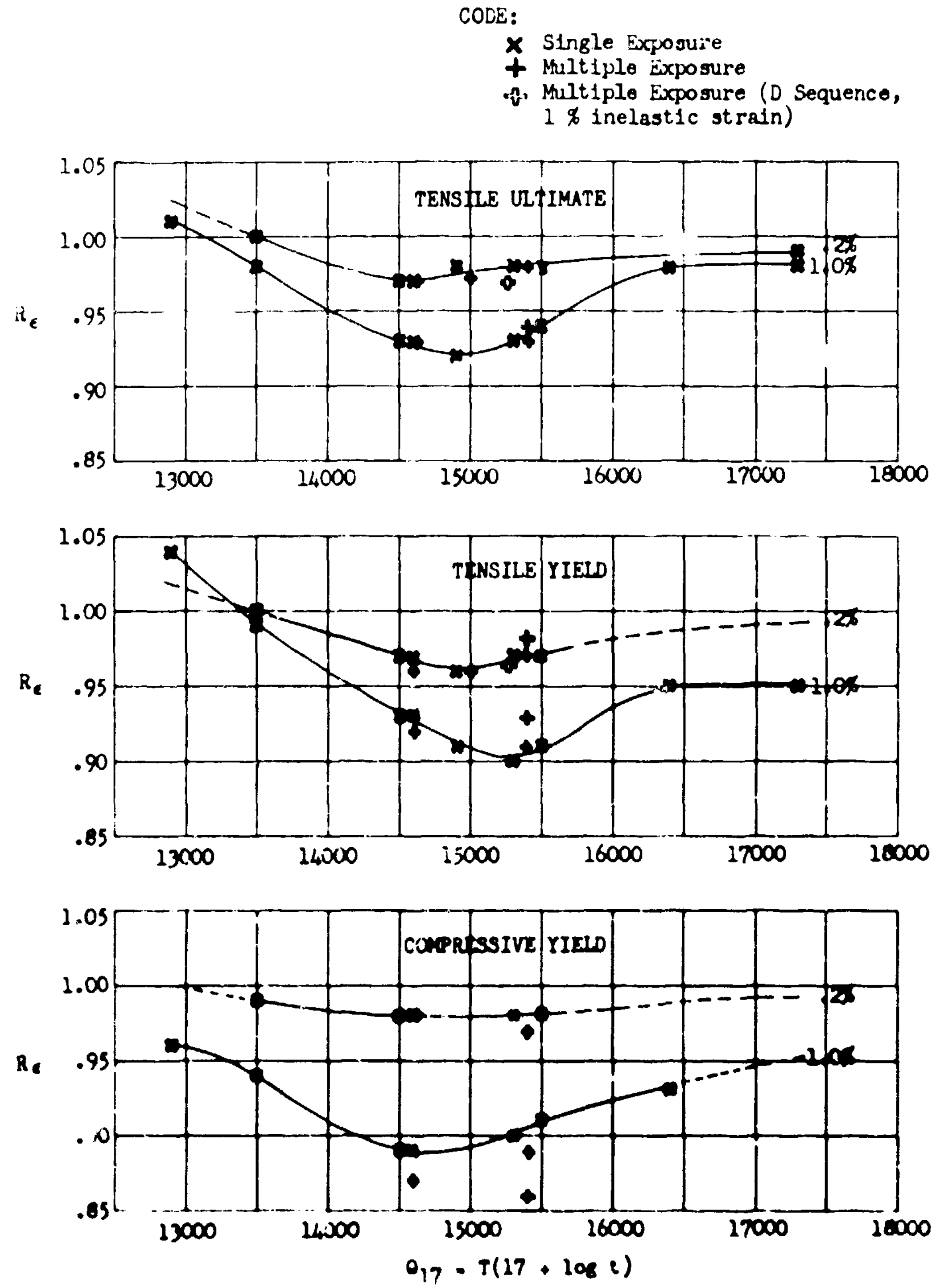


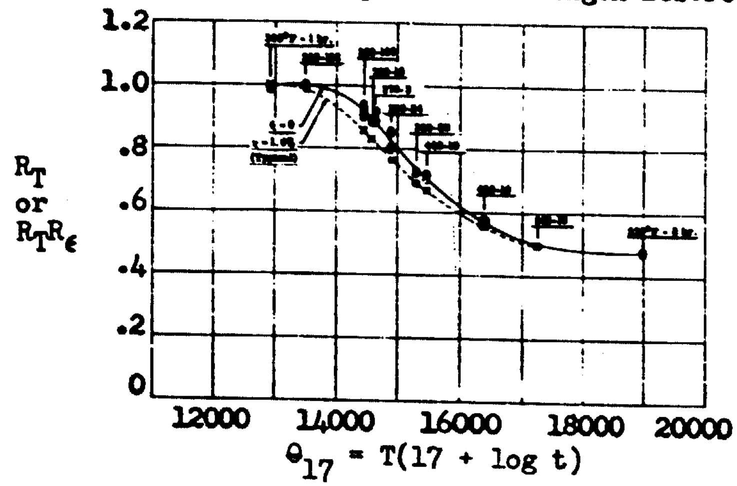
FIGURE 16 VARIATION OF STRESSED EXPOSURE EFFECTS WITH DEGREE OF EXPOSURE

$$R_T = \frac{\text{Strength at Temperature After Unstressed Exposure}}{\text{Room Temperature Strength Before Exposure}}$$

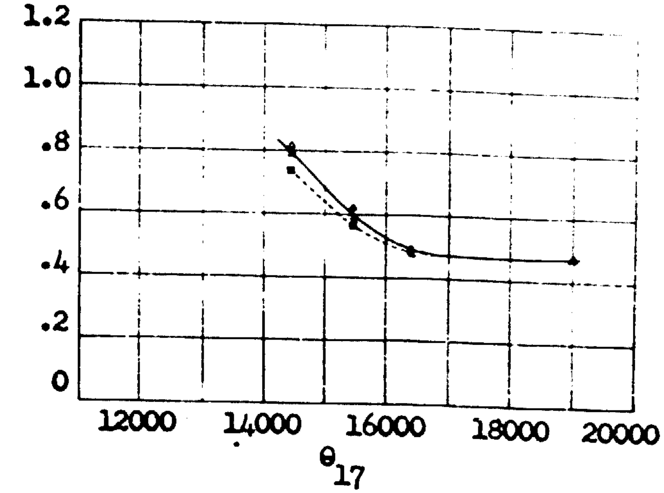
$$R_T R_\epsilon = \frac{\text{Strength at Temperature After Stressed Exposure}}{\text{Room Temperature Strength Before Exposure}}$$

$R_T R_\epsilon$ for ϵ = 1.0% - -

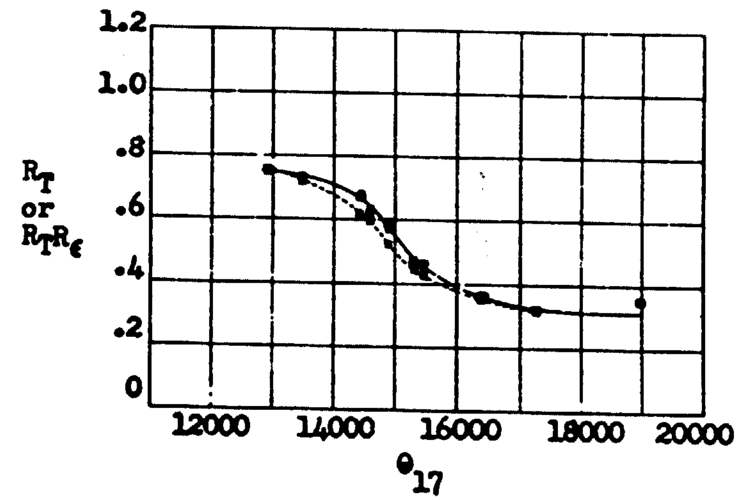
R_T for $\epsilon = 0$ ——



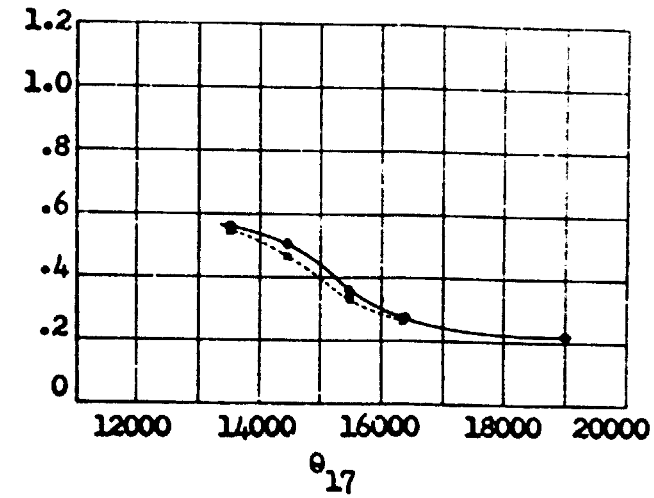
(a) Tensile Ultimate Strength at R.T.



(b) Tensile Ultimate Strength at 200°F

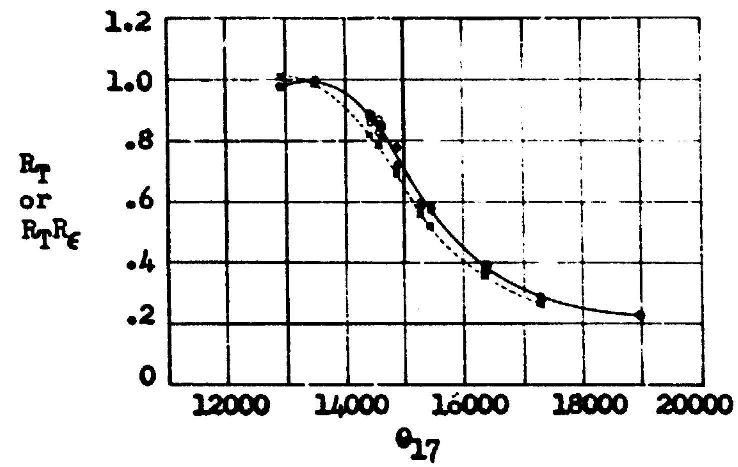


(c) Tensile Ultimate Strength at 300°F

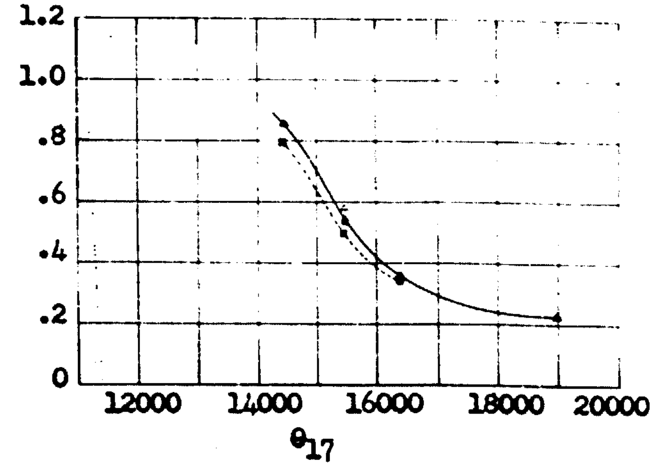


(d) Tensile Ultimate Strength at 400°F

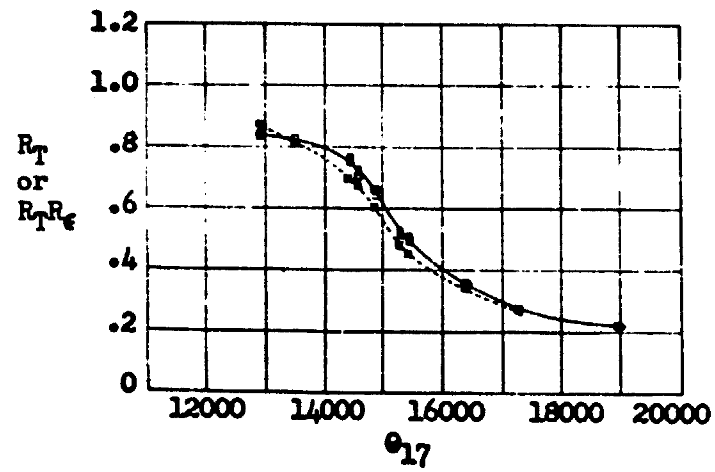
FIGURE 17 STRENGTH REDUCTION AFTER UNSTRESSED AND STRESSED SINGLE EXPOSURE



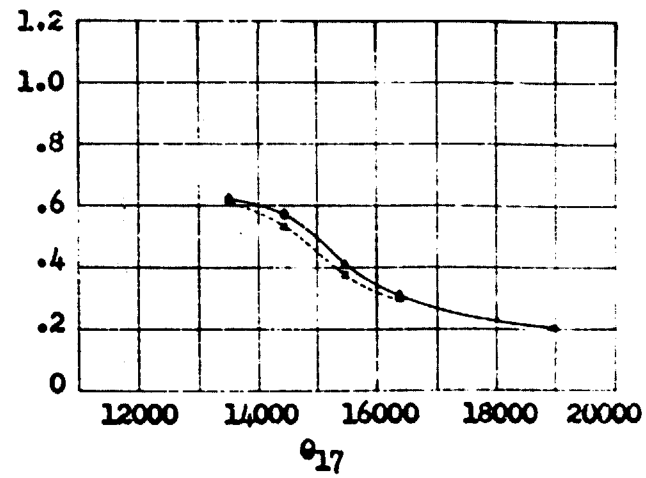
(e) Tensile Yield Strength at R. T.



(f) Tensile Yield Strength at 200°F

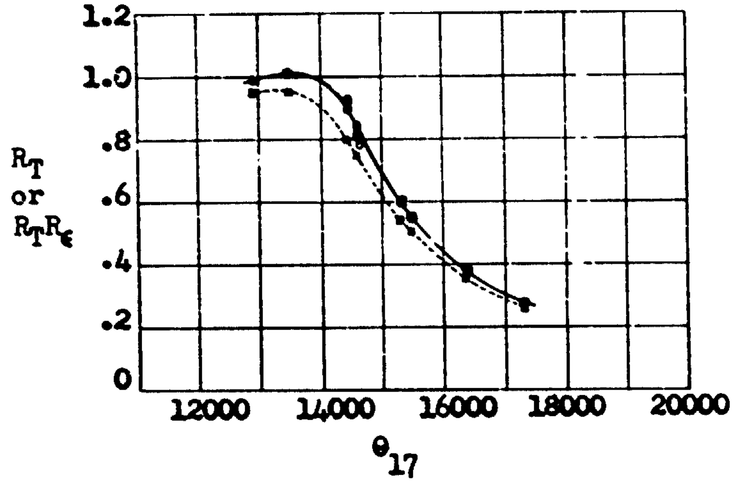


(g) Tensile Yield Strength at 300°F

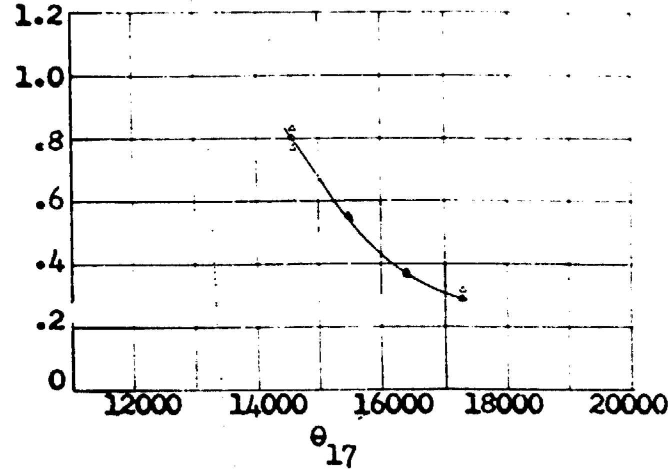


(h) Tensile Yield Strength at 400°F

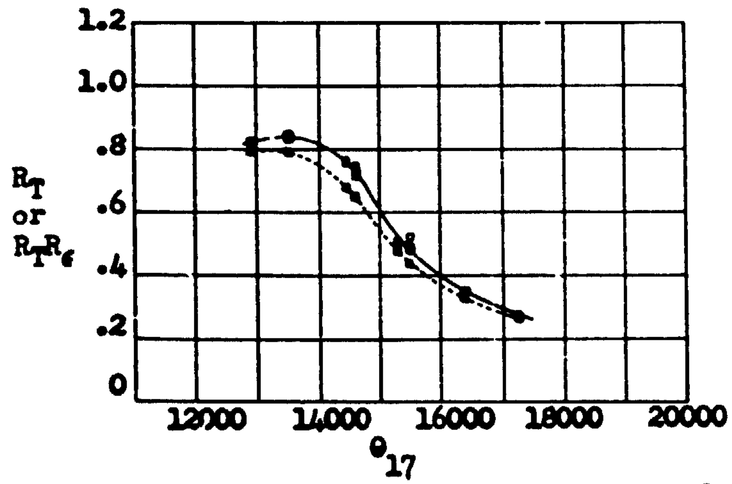
FIGURE 17 (Cont.) STRENGTH REDUCTION AFTER UNSTRESSED AND STRESSED SINGLE EXPOSURE



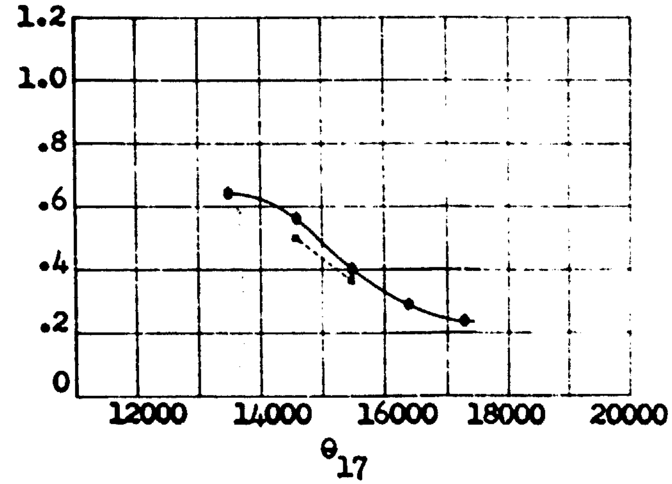
(i) Compressive Yield Strength at R. T.



(j) Compressive Yield Strength at 200°F

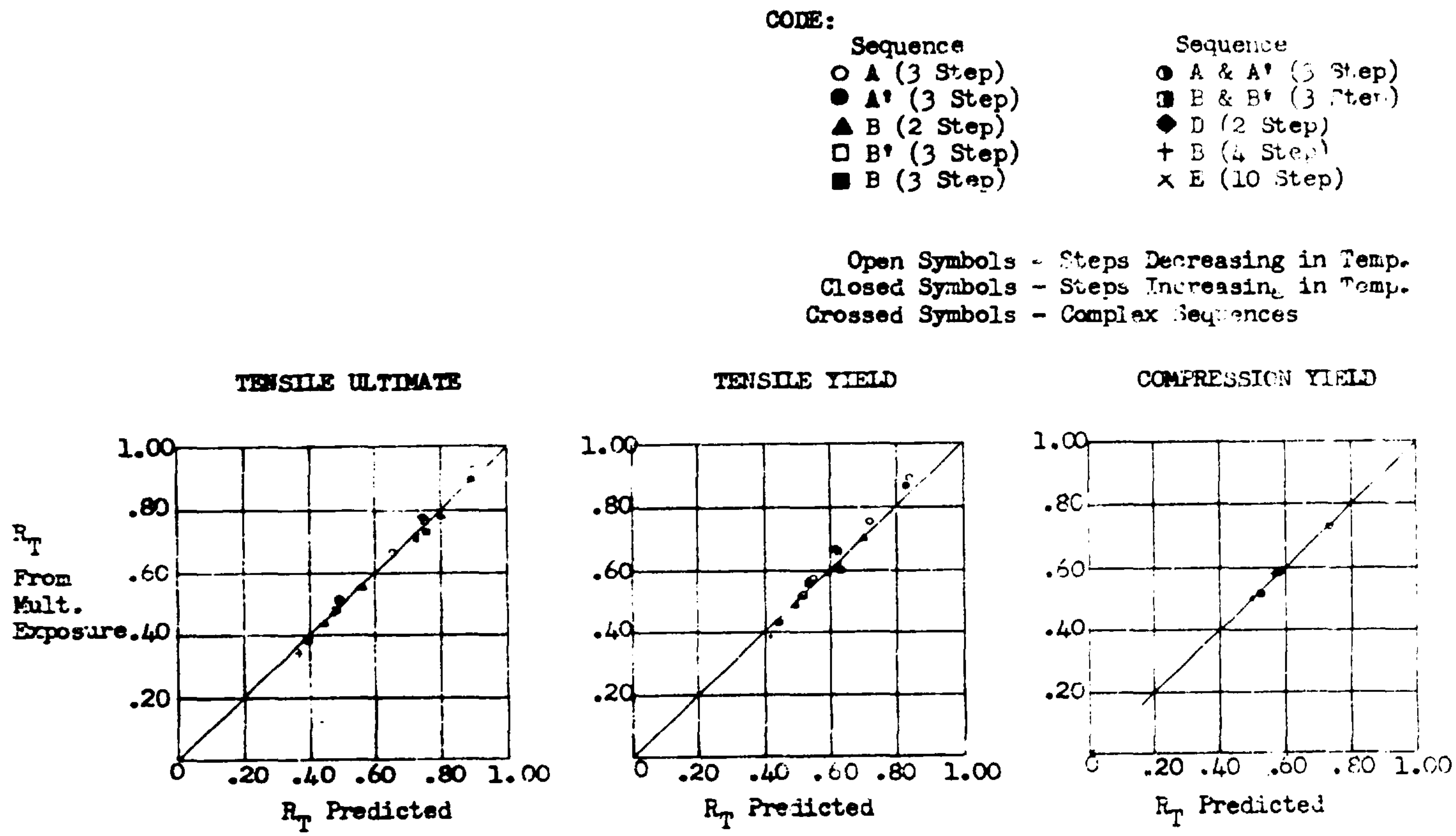


(k) Compressive Yield Strength at 300°F



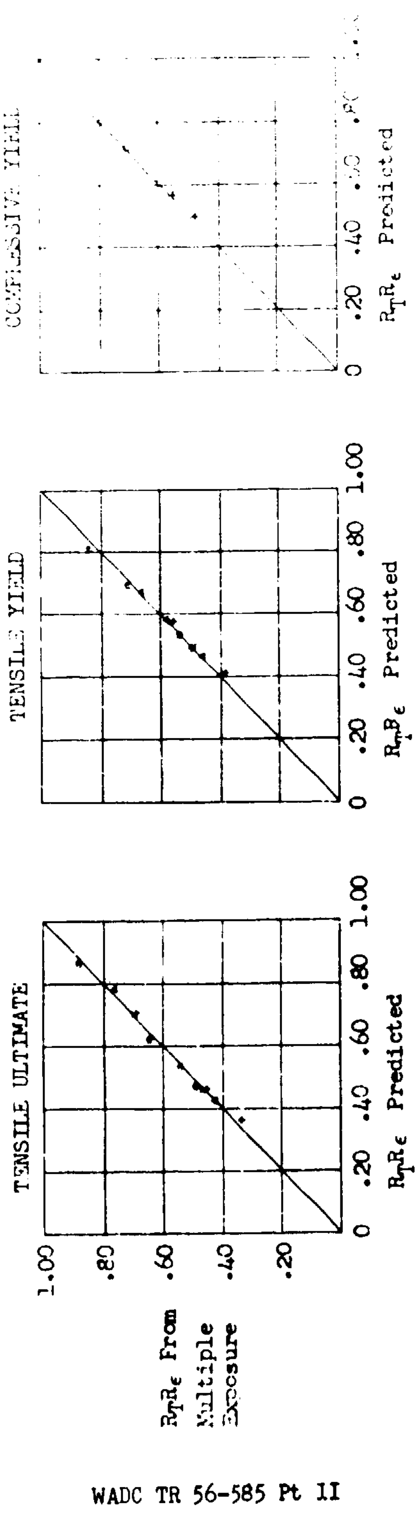
(l) Compressive Yield Strength at 400°F

FIGURE 17 (Cont.) STRENGTH REDUCTION AFTER UNSTRESSED AND STRESSED SINGLE EXPOSURE

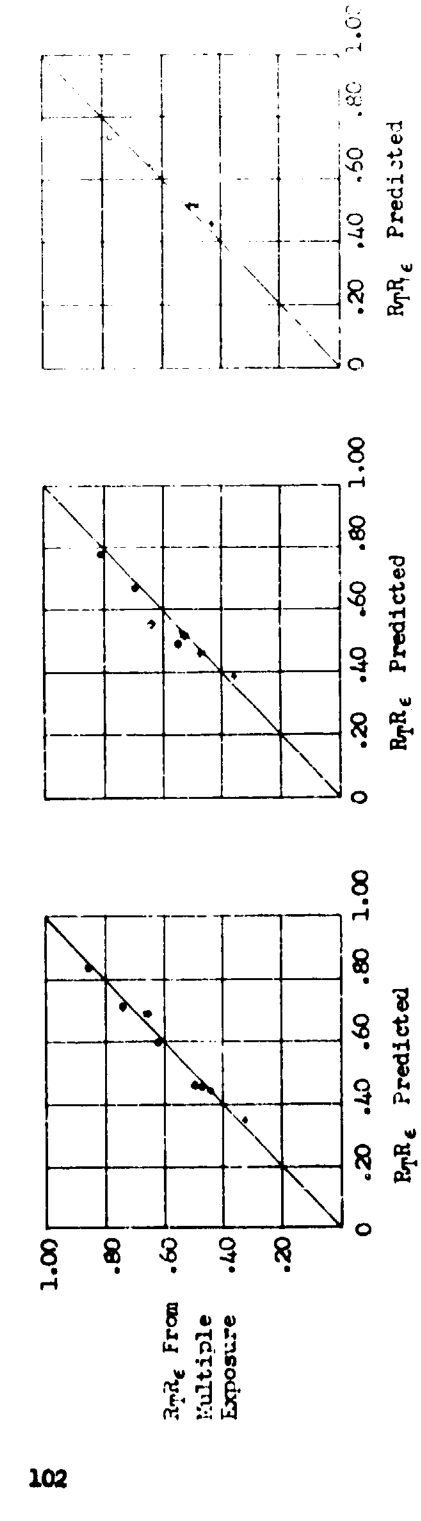


(a) Unstressed Multiple Exposure

FIGURE 13 COMPARISON OF STRENGTH AFTER MULTIPLE EXPOSURE WITH STRENGTH PREDICTED FROM SINGLE EXPOSURE CURVES

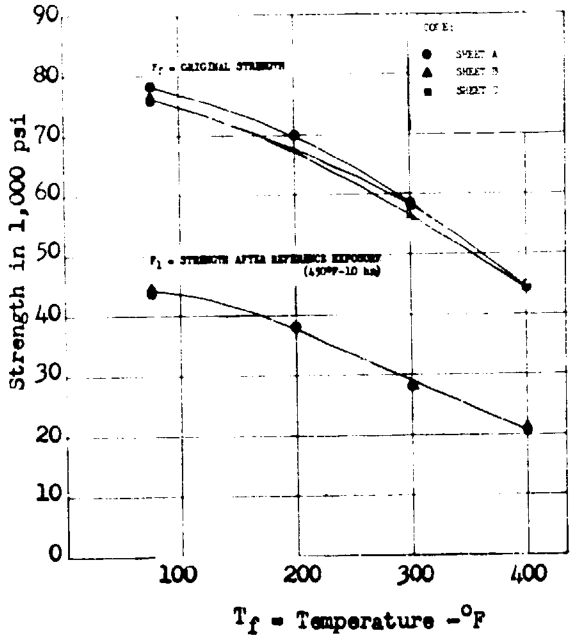


(b) **Stressed Multiple Exposure -- 0.2% Inelastic Strain**

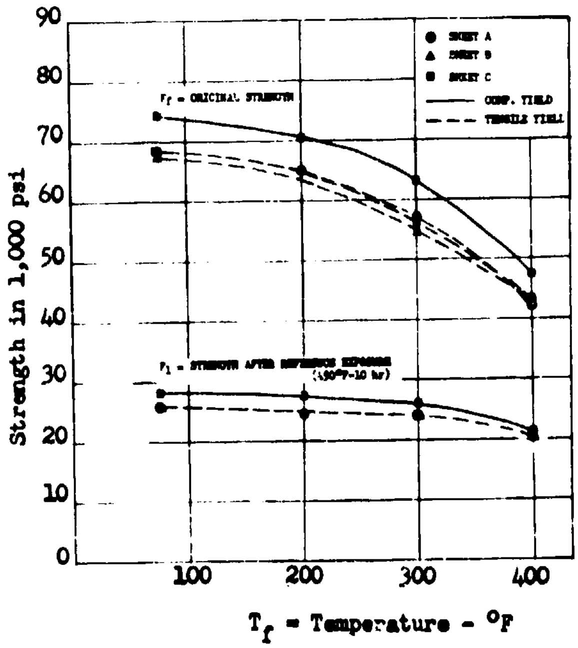


(c) **Stressed Multiple Exposure -- 1.0% Inelastic Strain**

FIGURE 18 (Cont.) COMPARISON OF STRENGTH AFTER MULTIPLE EXPOSURE WITH STRENGTH PREDICTED FROM SINGLE EXPOSURE CURVES

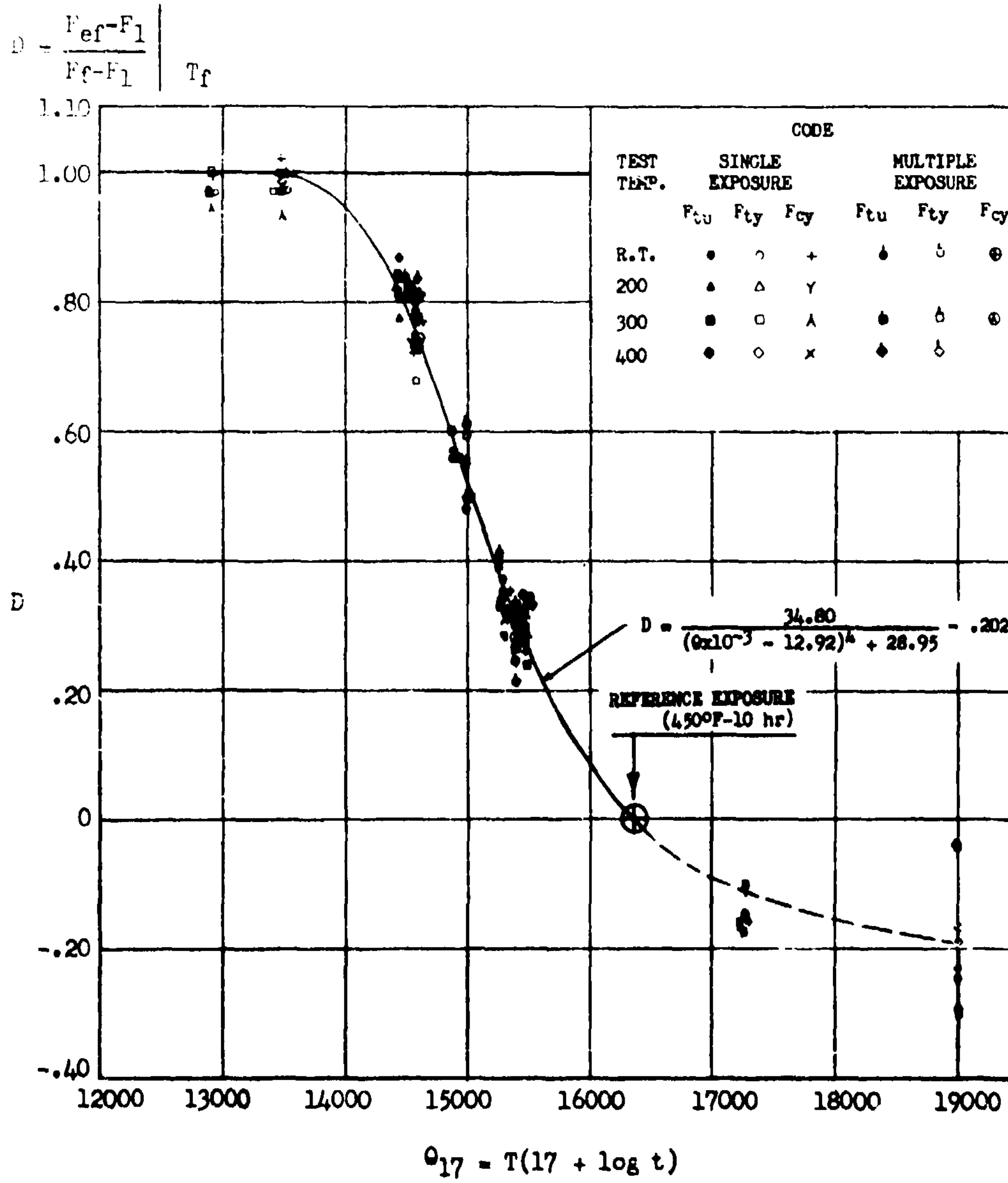


(a) Ultimate Tensile Strength



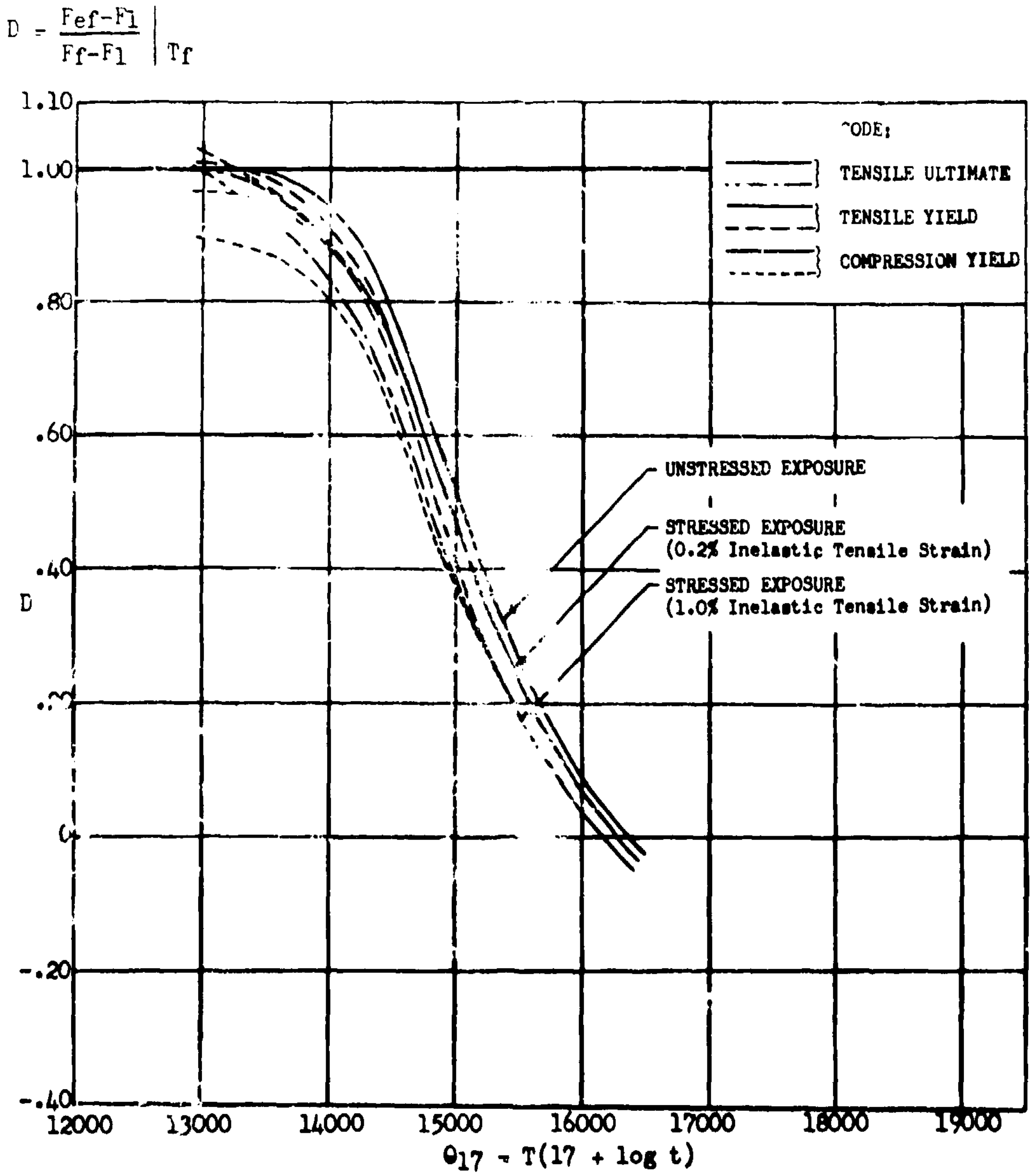
(b) Yield Strength

FIGURE 19 STRENGTH OF 7075-T6 AT TEMPERATURE BEFORE AND AFTER REFERENCE EXPOSURE



(a) **Unstressed Exposures**

FIGURE 20 STRENGTH DETERIORATION CHARACTERISTICS OF 7075-T6 AT ALL TEST TEMPERATURES



(b) Stressed Exposures

FIGURE 20 (Cont.) STRENGTH DETERIORATION CHARACTERISTICS OF 7075-T6 AT ALL TEST TEMPERATURES

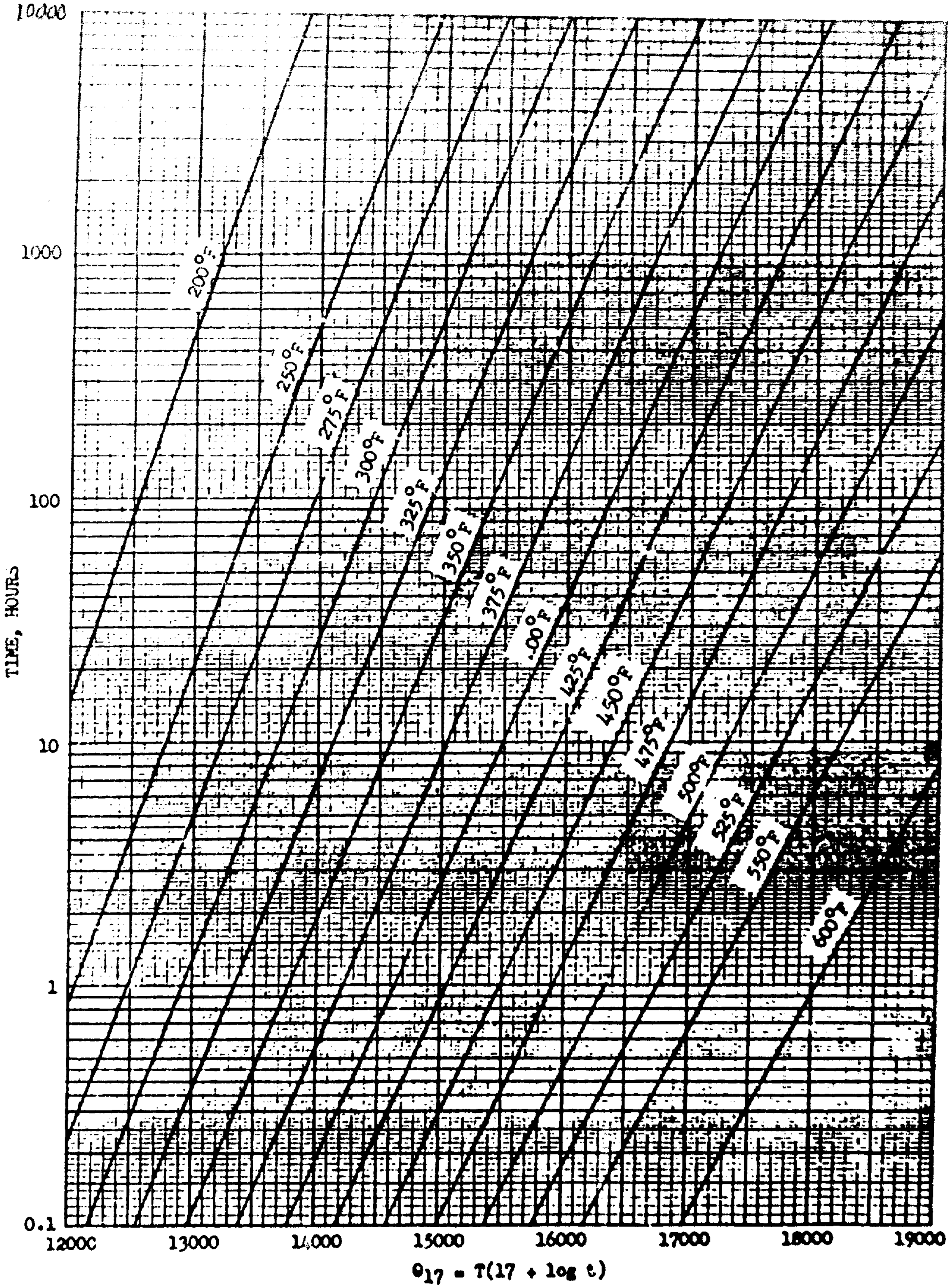


FIGURE 21 LARSON-MILLER PARAMETER DIAGRAM